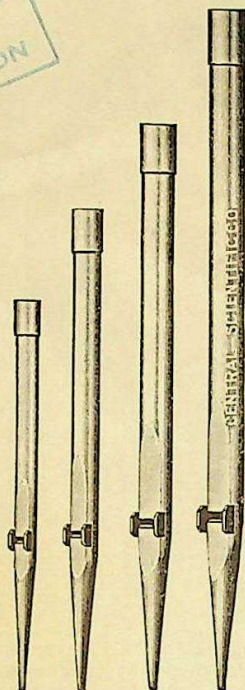
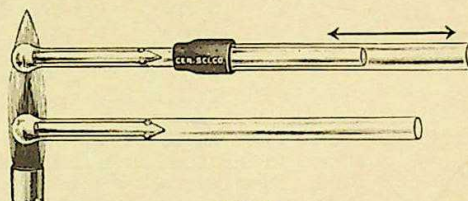


85165



85185-85200



85180

SOUND
Singing Tubes
Organ Pipes

85165 SINGING TUBES, Electric, Cenco, designed for the demonstration of resonating air columns in which the source of heat is a pair of electrically heated grids instead of gas flames. The two glass tubes are held side by side in clamps which permit ready adjustment relative to the source of heat. A specially constructed electric heater is mounted on a vertical rod by means of which the grids may be held in position at some distance from the lower end of the tube. The two grids are connected in series to a 115-volt current source. As soon as the current starts flowing, provided the tubes are in their correct positions relative to the grids, both tubes start and continue to emit a loud sound. The pitch of this note is slightly varied by adjusting the glass tube upward or downward a short distance. In this manner, the tubes may be tuned to unison, or slightly off unison, thereby producing loud beats.

The emission of sound from the tubes is brought about by the fact that as soon as the grids are heated, the upward current of air through the tube produces a cooling effect. The action is positive. Slight variations in the rate of this upward current produce a corresponding variation in the cooling effect on the wires in the grids, so that impulses are set up which, through the resonant response of the tube, are reinforced until a maximum is reached and sustained as long as the current is permitted to flow. The demonstration is striking and the apparatus is particularly suitable for use in a lecture demonstration or in a physics museum in which the visitor may be permitted to turn a switch, thereby turning on the current in the heater. Complete as illustrated.....**Each \$31.00**

10% discount in lots of 6

85180 SINGING TUBES, Cenco-Knipp, Small Form, consisting of a pair of singing tubes of straight form, one shorter than the other. The longer one is of the proper length to produce a sound of the greatest intensity. An extension tube of glass, slightly larger than the Singing Tube, is attached to the short tube by means of a piece of rubber tubing, which enables the effective length of the tube, and hence its pitch, to be varied as desired. The tubes, being small, require only a small flame, such as that of a Bunsen burner or alcohol lamp, to start them singing. The sound produced is very penetrating, and when beats are produced by the proper tuning of the shorter tube, the intensity of the beats is so great as to be almost painful. This provides a striking demonstration of the small amount of energy required to produce a sound of great intensity. The demonstrations that can be made with these Singing Tubes, small form, are: 1. The direct conversion of heat energy into sound. 2. The production of sound by means of a vibrating air column only. 3. The relation between the pitch of the sound and the length of the vibrating air column. 4. The phenomenon of beats.

Complete as described, with extension tube and rubber connection, in wooden case..**Per pair 3.00**

10% discount in lots of 6 pairs

85185 ORGAN PIPE, Metal, Open End. Length, 60 cm; diameter, 4.5 cm. This is one pipe of No. 85200 Set.**Each 5.60**

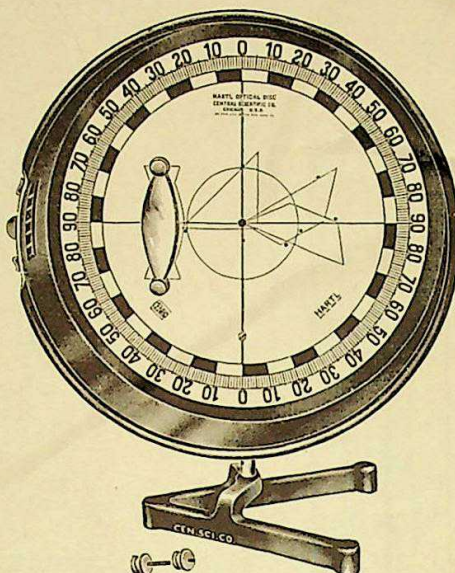
10% discount in lots of 6

85200 ORGAN PIPE SET, Metal, Open End, giving chord C', E', G', and C". Of substantial construction as used in pipe organs. Sliding tubes are provided for tuning. In sets of 4.....**Per set 21.00**

10% discount in lots of 6

359/896

LIGHT
Optical Disk



85245

85245 OPTICAL DISK, Hartl, (Trade Mark Reg. U. S. Pat. Off.) A complete laboratory in optics, designed to illustrate in a simple and perfect way the **fundamental laws of optics**. An intense beam of parallel rays is necessary, for which sunlight may be utilized either directly as it falls into the room through a partly shaded window, or reflected by means of a simple mirror. It is not necessary or desirable to use a darkened room. When direct sunlight is not available, No. 85261 Cenco Arc Illuminator is the most satisfactory source of artificial light. The paths of light rays shining across the 30 cm graduated aluminum disk and through the lenses and mirrors can be seen by the entire class.

The graduations to single degrees and the numbers are easily observed. The Hartl design permits the use of the optical disk in **either vertical or horizontal position**. A great variety of optical experiments may be performed with this apparatus. These experiments with a single ray or several parallel rays include the following:

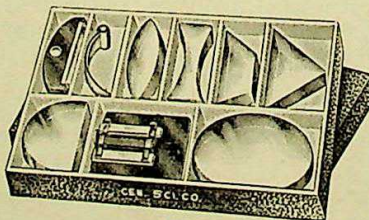
- | | |
|-------------------------------|--|
| 1. Angle of reflection. | 10. Stereo binocular. |
| 2. Angle of refraction. | 11. Refraction through a parallel plate. |
| 3. Index of refraction. | 12. Refraction through a prism. |
| 4. Total reflection. | 13. Porro prism system. |
| 5. Critical angle. | 14. Measurement of the angle of a prism. |
| 6. Refraction through lenses. | 15. Dispersion showing spectrum. |
| 7. Caustic of lenses. | 16. Theory of the rainbow, formation of primary and secondary bow. |
| 8. Principal rays. | |
| 9. Principal focus of lenses. | |

The set of accessories furnished includes the following:

- | | | |
|------------------------------|-----------------------|--------------------|
| 1 Plane Mirror, Mounted. | 1 Circular Lens. | 2 Slotted Plates. |
| 1 Concave and Convex Mirror. | 1 Semi-circular Lens. | 2 Opaque Sliders. |
| 1 Double Convex Lens. | 1 Prism, 45° and 90°. | 2 Colored Screens. |
| 1 Double Concave Lens. | 1 Prism, 45° and 60°. | |

Complete as described, with fully illustrated pamphlet containing detailed directions for use. Each \$40.00

5% discount in lots of 3

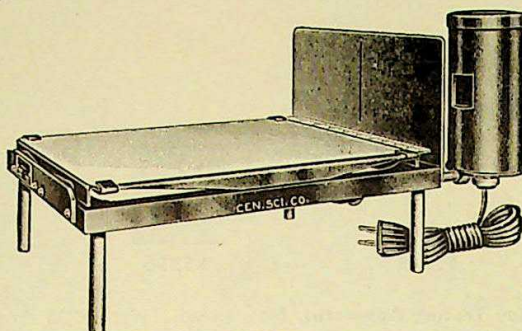


85252

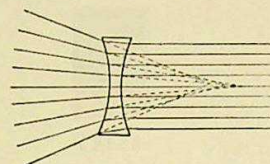
85252 Optical Disk Accessories, only, of No. 85245 Hartl Optical Disk, as described above.....Per set 17.75
10% discount in lots of 6

LIGHT Ray Tracing Apparatus

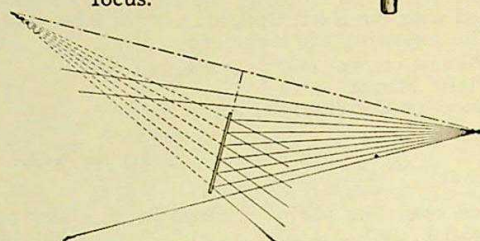
Trace of parallel rays through a converging lens showing principle focus.



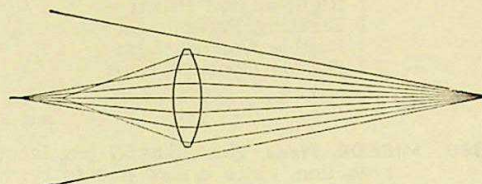
85331



Trace of parallel rays through a diverging lens showing virtual focus.



Trace of reflection of diverging rays from plane mirror, showing image of a point.



Trace of diverging rays through converging lens, showing image formation.

85331 RAY TRACING APPARATUS, Cenco-Minor, for experimental study by the individual student of the phenomena of reflection and refraction of light. The student charts the paths of a narrow beam of light on a sheet of notebook paper placed on the platen of the apparatus, striking a mirror, prism, or lens at various points on the reflecting or refracting surface, and from the lines designating the paths makes his computations.

The apparatus consists of a heavy metal support on four white-plated legs, a movable metal platen with engraved millimeter scale, a light shield with narrow vertical slit and a light source enclosed within a metal housing. The platen is provided with spring clips for securely holding a sheet of notebook paper of the standard 8½ by 11-inch size. The engraved millimeter scale is mounted on the end of the platen nearest the light screen, to aid the student in uniformly spacing his traces. It is numbered in centimeters both ways from a center zero. The platen is easily shifted to the right or left of the slit and is firmly held in the desired position by strip springs on the support frame. The light shield with single slit is easily detached from its support by loosening two knurled thumb screws. No. 85332 Diverging Ray Attachment is interchangeable with the single-slit light shield. The light source is attached to the apparatus by a metal arm, which is adjustable for distance and angle of the lamp relative to the light shield. Line-source illumination is secured from a No. 84458, a coil filament incandescent lamp which attaches to the standard medium-screw base socket for operation on 115 volts A.C. or D.C.

In use, either No. 85334 Lenses and Mirrors or the corresponding optics of No. 85245 Hartl Optical Disk may be studied with the apparatus. The lens, mirror or prism is placed upon a sheet of paper clipped to the platen and its outline drawn by running a pencil along the reflecting or refracting surfaces. The light and platen are adjusted relative to each other to produce a ray of light on the platen perpendicular to the millimeter scale. The ray, before and after reflection and refraction, is located by pencil dots on the paper, which are later connected by straight lines. The platen is then shifted 5 or 10 mm, as shown by the scale, and the next position of the ray located. This may be repeated for any desired number of rays. The process is so simple that the average student may easily plot from 5 to 10 sets of ray systems in a single laboratory period. Diverging incident rays may be similarly plotted through the use of No. 85332 Diverging Ray Attachment. For experiments using this apparatus, see Experiments 4, 5, and 11, "Laboratory Exercises in Geometrical and Physical Optics," by Ralph S. Minor and Harvey E. White.

Complete with incandescent lamp for 115 volts, but **without** diverging ray attachment or optical parts Each \$41.00

10% discount in lots of 6

For experiments employing this or similar apparatus, see S. E. P. L31ab. See list of Manual References, page 1000.

85332 Diverging Ray Attachment, Cenco-Minor, for use with No. 85330 Ray-Tracing Apparatus for tracing divergent incident rays. This makes possible, for example, the experimental study of conjugate foci, and direct application of the lens and mirror formulas to the results, also the experimental study of image formation. The simplicity of the attachment highly commends it.

The Diverging Ray Attachment is an additional light shield, interchangeable with the one regularly supplied with the Ray-Tracing Apparatus; but instead of containing a single narrow slit, it contains nine such slits, all parallel and centrally located. This produces nine narrow beams, all coming from the single filament source, the divergence of the beam depending on the distance of the lamp from the light shield..... Each 2.60

10% discount in lots of 6

Lamp for Replacement in No. 85331, See No. 84458.

LIGHT
Mirrors

85380



85385



85390



85395

85334 Mirror and Lens Set, Ray Tracing Apparatus, for use with No. 85331 Apparatus. Consists of a selection of the optical accessories from the set supplied with the Hartl Optical Disk for those who do not have that set of optical disk accessories. The following are included:

- | | |
|-----------------------|------------------------------------|
| 1 Right-angled Prism | 1 Plano-Convex (Semicircular) Lens |
| 1 Erecting Prism | 1 Plane Mirror |
| 1 Double Convex Lens | 1 Concave-Convex Mirror |
| 1 Double Concave Lens | |

As described Per set \$13.15

10% discount in lots of 6

85380 MIRROR, Plane, glass, 8.5x5.7 cm, lacquered black on one side; useful in studying the laws of reflection, since errors due to refraction are avoided. Each .14

10% discount for Cenco Package of 50

85385 MIRROR, Plane, glass, 4x15 cm, silvered back Each .08

10% discount for Cenco Package of 50

85390 MIRROR, Plane, glass, 10x10 cm, silvered back Each .08

10% discount for Cenco Package of 50

85395 MIRROR, Plane, thick plate glass, 10x15 cm, silvered back, for double images. Each .70

10% discount in lots of 12



85405



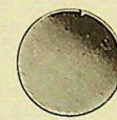
85407



85415



85420



85425

85405 MIRROR, Spherical, Concave, High Quality, glass, 4 cm in diameter, 25 cm focus, silvered back. Each .70

10% discount for Cenco Package of 12

85407 MIRROR, Spherical, Concave, Demonstration Type, for showing the properties of concave mirrors by means of a mirror of unusual size, for more effective class demonstrations. Consists of a back-silvered, glass concave mirror, 16 inches in diameter, having a focal length of approximately 37 cm. Each 4.25

10% discount in lots of 6

85415 MIRROR, Spherical, Convex, High Quality glass, 4 cm in diameter, 25 cm focus, silvered back. Each .65

10% discount for Cenco Package of 12

85417 MIRROR, Spherical, Convex, Demonstration Type, for showing the properties of convex mirrors by means of a mirror of unusual size, for more effective class demonstrations. Consists of a back-silvered, glass convex mirror, 16 inches in diameter, having a focal length of approximately 37 cm. Each 3.85

10% discount in lots of 6

85420 MIRROR, Spherical, Plane and Concave, Mounted, glass, 5 cm in diameter, 7.5 cm focus silvered backs. Mounted on a metal rod about 18 cm long by 10 mm in diameter. Mirror adjustable about a horizontal axis. Each 12.25

10% discount in lots of 6

85425 MIRROR, Spherical, Concave and Convex, glass, 7.5 cm in diameter, 20 cm focus. Each .40

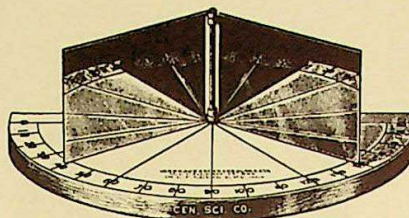
10% discount for Cenco Package of 25

LIGHT
Mirrors

85435



85440

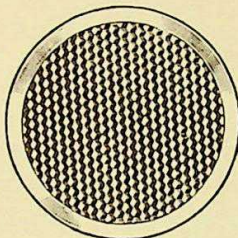


85445

- 85435 MIRROR, Concave**, for use in student experiments with No. 85755 Student's Optical Bench. Consists of a blackened glass, plano-concave mirror mounted in a frame having a rod $1\frac{1}{4}$ inches long, which fits into No. 85905 Mirror or Lens Support.....Each \$2.00
10% discount in lots of 6

- 85440 MIRROR, Cylindrical, Concave and Convex**, brass, heavily nickeled, 5x10 cm.....Each 1.00
10% discount for Cenco Package of 12

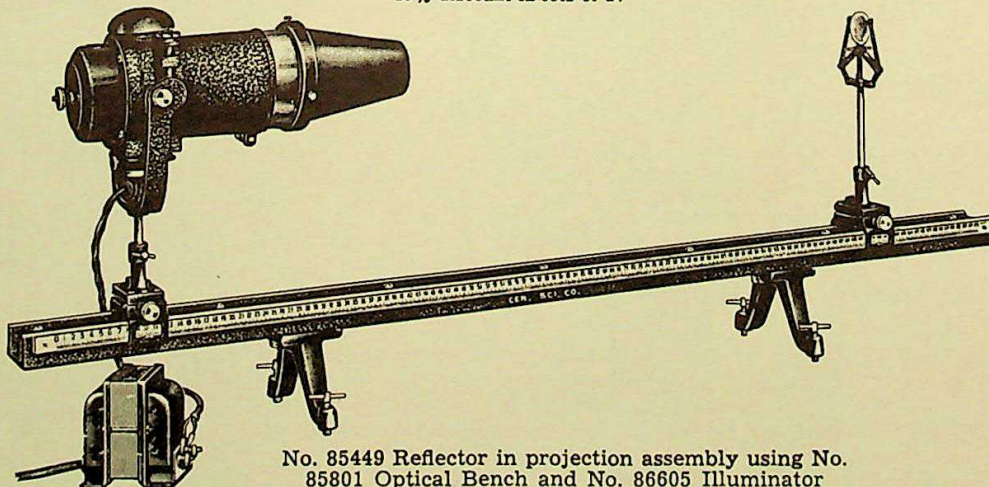
- 85445 MULTIPLE IMAGE APPARATUS**. Two hinged metal mirrors on semi-circular base of about 18 cm radius, to which is attached a chart graduated for illustrating multiple reflections..Each 14.00
10% discount in lots of 6



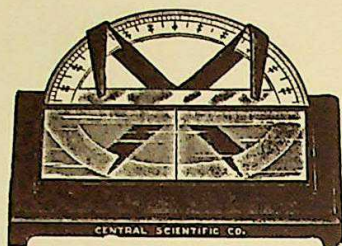
85449

- 85449 AUTO-COLLIMATING REFLECTOR**, for demonstrating reflection of light along the line of incidence as total internal reflection. This reflector consists of a disk approximately $1\frac{1}{8}$ inches in diameter, of transparent molded material mounted on a plastics backing. One side is smooth and polished; the other consists of many small, pyramidal projections in which the three sides of the pyramid meet at 90 degrees. The axis of each pyramid is perpendicular to the smooth side. Of these reflectors there are 300 per square inch. Light falling on the smooth side passes through, strikes the inner surface of a pyramid, is reflected at right angles to another inner surface, and then back in the direction from which it came. This is true within wide limits, regardless of the angle of incidence of the light.

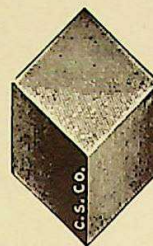
This material is used in warning signals attached to automobiles and in automobile tail lights, since it has the property of reflecting light with high intensity back to the driver of a car approaching from the rear. This material also has the interesting property of permitting light to pass rather freely in one direction when emerging from the smooth side; but light passing in the opposite direction is much diminished in intensity because most of it is reflected internally from the small pyramidal projections.....Each .50
10% discount in lots of 24



No. 85449 Reflector in projection assembly using No. 85801 Optical Bench and No. 86605 Illuminator

LIGHT
Prisms

85450



85500

- 85450 INCIDENCE AND REFLECTION APPARATUS.** Consists of a graduated semi-circle mounted on a heavy metal base, 8.5x16 cm, with mirror. Provides a simple method of proving the law of reflection. The angle of incidence is easily read from a graduated scale which can be quickly set at any angle. **Each \$8.00**

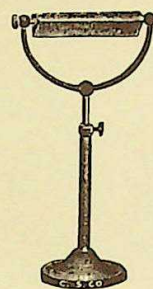
10% discount in lots of 6

- 85500 GLASS CUBE,** for index of refraction experiments; 5 cm on each edge. **Each 1.90**

10% discount for Cenco Package of 12



85505-10



85507

- 85505 PRISMS, Equilateral, Flint Glass,** for experiments in diffraction, dispersion and spectrum formation by means of a prism. The larger sizes are excellent for use in lecture demonstrations.

No.	A	B	C
Width of face, mm	28	25	25
Length, mm	75	100	150
Each	1.05	1.15	1.70

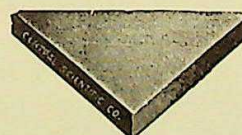
10% discount in lots of 12

- 85507 PRISM, Equilateral, Mounted.** No. 85505 Prism so mounted that it may be placed with its axis either vertical or horizontal and rotated about its axis in either position. The prism is adjustable vertically through a range of about 20 to 30 cm above the table. **Each 6.75**

10% discount in lots of 6



85520



85525

- 85510 PRISM, Equilateral, Lucite,** for spectrum projection and demonstrations in color. Made of transparent methyl methacrylate resin in which the refractive index is high and the critical angle is quite large. Produces a brilliant spectrum from a source of light like Nos. 85261, 85262 or 86605 Illuminators. A bright line spectrum of mercury is produced when No. 87268 Mercury Arc Lamp is used as a light source. Length, 125 mm; width of faces, 55 mm. **Each 8.25**

10% discount in lots of 6

- 85511 PRISM, Equilateral, Lucite,** same as No. 85510, but 40x55 mm in size. **Each 4.25**

10% discount in lots of 6

- 85520 PRISM, Right Angle,** for total reflection, flint glass, angles of 45 and 90 degrees; widest face, 32 mm; length, 50 mm. **Each .95**

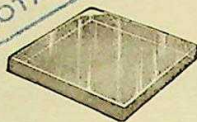
10% discount for Cenco Package of 12

- 85525 PRISM, Equilateral,** for index of refraction experiments; 75 millimeter face, 9 millimeters thick. **Each .75**

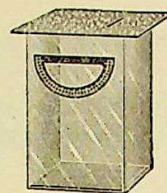
10% discount for Cenco Package of 12

LIGHT
Refraction

PRICES CHANGED
WRITE FOR QUOTATION



85540



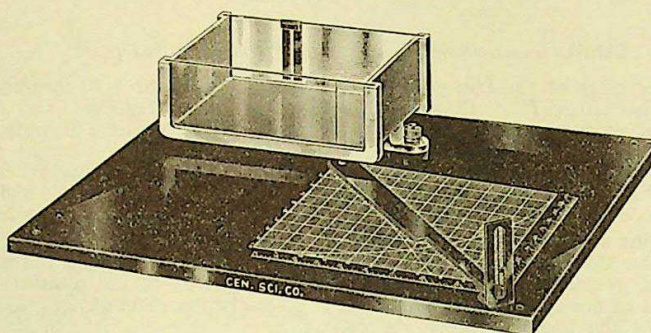
85545

85540 INDEX OF REFRACTION PLATE, Hall. Glass plate 7 cm x 7 cm x 6 mm. Two opposite edges are polished, the others ground. A simple yet effective plate for determining the index of refraction of glass. Can be used for this purpose with No. 85555 Refraction Apparatus. **Each \$0.30**

10% discount for Cenco Package of 36

85545 REFRACTION TANK. A glass jar about 6.5x10.5x17.5 cm, with flat faces, one side being provided with a protractor. Supplied with a metal cover provided with a narrow slit for admitting a beam of light into the jar. **Each 3.50**

10% discount in lots of 6



85555

85555 REFRACTION APPARATUS, Cenco, for conveniently making successive readings of the angles of incidence and refraction in a liquid. A metal tank 15 cm long x 10 cm wide x 5 cm deep with parallel glass sides is mounted on a pressed metal base, which is provided with scale, protractor and swinging index arm. The scale and protractor are lithographed in white on the dull black background of the metal base for maximum contrast and legibility. A metal slit slides along the rear glass plate, and by swinging the index arm is brought into line with a scratch on the front plate and a cross-wire on the swinging arm. When the tank is partly filled with the liquid whose index of refraction is desired, the angle of incidence in the liquid is read by sighting **above** the surface of the liquid, and the angle of refraction by sighting **through** the liquid. In this way a great number of independent values may be obtained, at angles of incidence varying from zero degrees almost up to the critical angle, without the necessity of removing the liquid each time.

The values of the sines of the angles may be read directly on the scale, or the angles themselves may be read and their sines obtained from a table of trigonometric functions. With a special sliding slit, the index of refraction of glass may be obtained by use of a plate with plane parallel sides. (See Nos. 85500 or 85540.)

Complete with two slits and directions for use. **Each 28.00**

10% discount in lots of 6

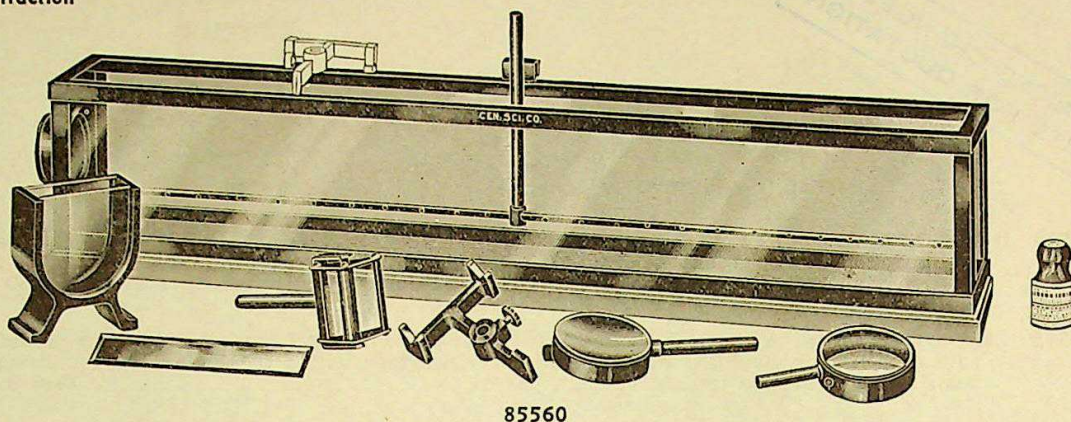
85560 REFRACTION TROUGH, Cenco-Minor, for experiments in the refraction and reflection of light. This Cenco specialty is an apparatus which Dr. R. S. Minor has exclusively authorized us to manufacture and sell. It is particularly helpful in giving the student a clear understanding of the fact that refraction is the result of a change in velocity of light as it passes from one transparent medium to another. Its design, both as to features and dimensions, is such that its usefulness is threefold: first, it can be shown to a class studying a first course in physics, in the demonstrations mentioned; second, it can be used as a laboratory device for a study of refraction at a single spherical surface, and of other refraction phenomena; third, it can be used in a demonstration of the polarization of scattered light.

The Cenco-Minor Refraction Trough is about 27 inches long, 5 3/4 inches high, and 5 3/4 inches wide inside. The sides and one end are transparent, the end being made of selected plate for freedom from optical defects. The other end is closed with a metal plate on which is mounted a holder with a thin plano-meniscus lens, with a diameter of about two inches. This makes possible experiments in refraction at a curved boundary between optically different media. The trough is well constructed and strong, and all joints are carefully sealed with waterproof cement.

With the Refraction Trough are furnished a number of accessories, with which the demonstrations and experiments can be carried out. These consist of (a) a clamp support, sliding

(Continued on next page)

**LIGHT
Refraction**



85560

85560 REFRACTION TROUGH, Cenco-Minor (Continued from previous page.)

on the upper edge of the trough, with clamping means for a 10 mm rod; (b) a hollow (air) prism; (c) a hollow (air) double convex lens; (d) a hollow (air) double concave lens; (e) a vessel with parallel glass sides, for holding refracting liquids; (f) filling tube for introducing a solution of greater density below water to show bending of ray of light passing through layers of different densities. In addition there are required one or more No. 72288 Lens and Mirror Holders, No. 85645-8 Double Convex Lens, No. 85650E Double Concave Lens, Nos. 85405 and 85415 Spherical Mirrors, and No. 85390 Plane Mirror.

The photographs shown on the next page are illustrative of the demonstrations that are possible with the Cenco-Minor Trough. They were made by using a plate or card with a series of holes in a vertical line at one end of the trough, to obtain a number of parallel "rays." A few drops of eosin in the water make it strongly fluorescent. In the trough containing air, smoke makes the beams clearly visible.

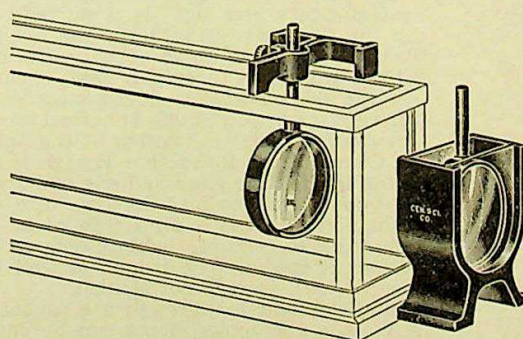
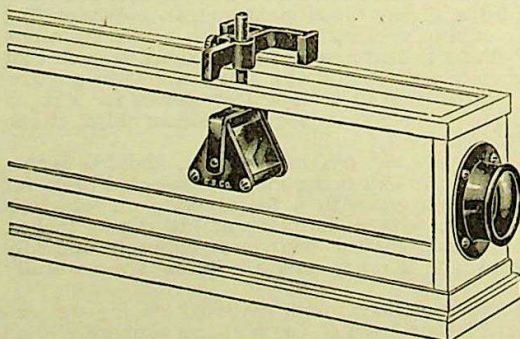
Complete with clamp support, hollow prism, double convex air lens, double concave air lens, parallel-sided tank, filling tube, strip of plane mirror and one ounce of eosin solution. **Each \$81.00**

5% discount in lots of 3

For experiments employing this or similar apparatus see M. & W. Exp. 1, p. 1., Exp. 3, p. 10; Min. Exp. 93, p. 128; D. C. M. Exp. 4, p. 23; S. E. P. L31b. See list of Manual References, page 1000.

Accessories for Use with No. 85560

85564	Lens, Air, Double Concave, 6.2 cm in diameter.....	Each 6.75
	10% discount in lots of 6	
85566	Lens, Air, Double Convex, 6.2 cm in diameter.....	Each 8.50
	10% discount in lots of 6	
85568	Prism, Air, with plane glass faces $3\frac{1}{2} \times 5$ cm.....	Each 12.75
	10% discount in lots of 6	
85572	Holder for lenses, prism, and mirrors used in connection with No. 85560.....	Each 5.15
	10% discount in lots of 6	
85574	Parallel Sided Tank for holding kerosene and other liquids. Height, $7\frac{1}{2}$ cm; width, 7 cm; thickness, 3 cm.....	Each 8.25
	10% discount in lots of 6	



85560 shown in typical experimental arrangement



Fig. 1



Fig. 2

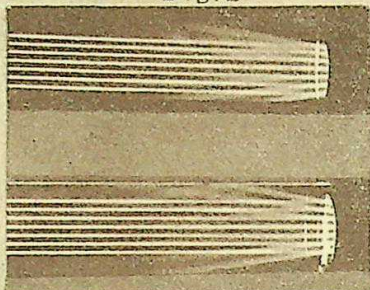


Fig. 3

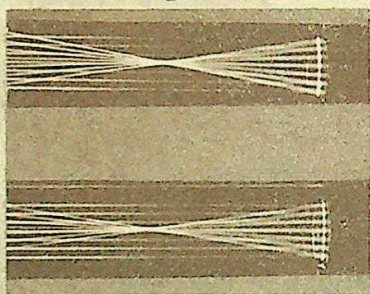


Fig. 4



Fig. 5

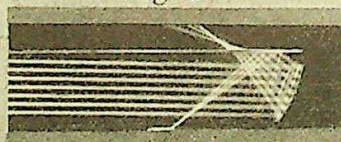


Fig. 6

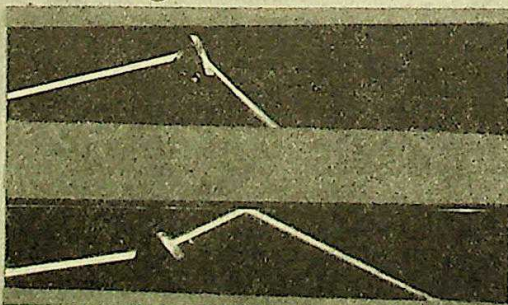


Fig. 7

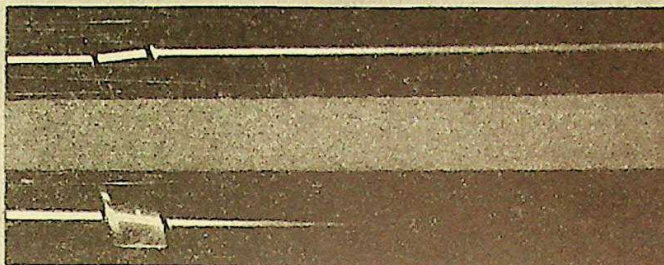


Fig. 8

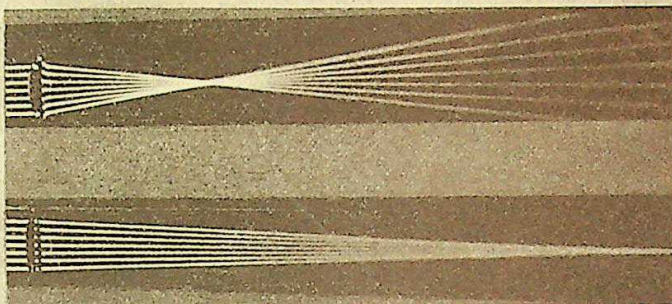


Fig. 9

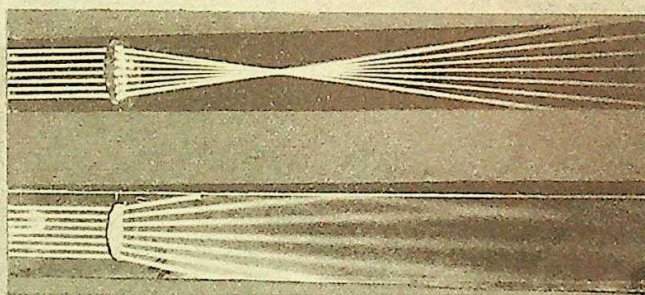


Fig. 10

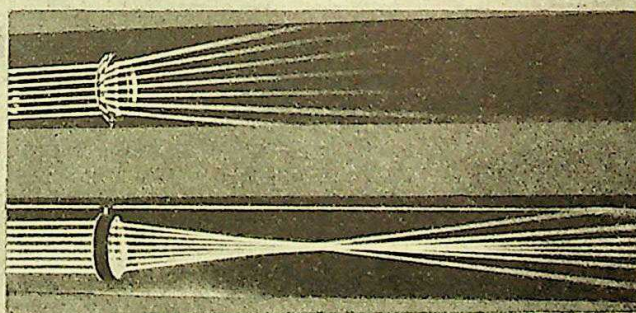


Fig. 11



Fig. 12

(Refraction patterns described on next page.)

LIGHT

Refraction

PHOTOGRAPHS OF NO. 85560 REFRACTION TROUGH IN USE

Halftone reproductions on preceding page were made from unretouched photographs

Fig. 1. Reflection of Ray of Light in Water. The ray, entering at left, strikes a plane mirror, and is reflected upward to the water surface, thence downward. In each case the angles of incidence and reflection are equal.

Fig. 2. Reflection of a convergent Bundle of Rays at a semi-silvered plane mirror. Part of the light passes through the mirror, and part is reflected. In both bundles the focal point is equally distant from the mirror surface. The convergence, or the curvature of the wave front, has not been changed by the reflection.

Fig. 3. Reflection of a Parallel Bundle of Rays at a convex mirror in air (above) and in water (below). The divergence of the rays is the same regardless of the medium in which the mirror is placed.

Fig. 4. Reflection of a Parallel Bundle of Rays at a concave mirror in air (above) and in water (below). Change of direction at reflection is independent of the medium. The focal length in the lower picture is slightly greater than in the upper, however, because the mirrors were back-silvered, and there was some refraction at the front surface.

Fig. 5. Critical Angle. A diverging bundle of rays strikes the water surface from beneath. Each ray, beginning at the top, is refracted through a larger angle than the preceding one. The angle at which the fourth ray strikes the water is so great that the ray can no longer emerge, but is totally reflected downward. A ray lying between the third and fourth from the top would strike the water surface at the critical angle.

Fig. 6. Critical Angle. A converging bundle of rays strikes the water surface from beneath. The rays which emerge from the water surface converge more rapidly than do those which are totally reflected. The curvature of the wave has been changed by refraction but not by reflection, at the water surface.

Fig. 7. Refraction by Prisms. Above: Glass prism in air. At the entering point the ray bends towards the normal to the refracting surface, and at the point of emergence it bends away from the normal. Below: Hollow (air)

prism in water. Bending of the ray takes place away from the normal at the first surface, and towards the normal at the second surface. The respective net results are that with the glass prism in air the ray is bent towards the base of the prism, and with the hollow prism in water the ray is bent towards the apex. In the lower photograph note the total reflection of the ray from the lower side of the water surface.

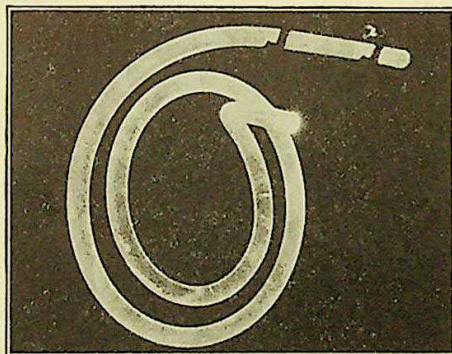
Fig. 8. Refraction at Parallel Surfaces. Above: The ray passes through a parallel-sided water cell in air. Note refraction towards the normal at the entering point, and away from the normal at the point of emergence. Below: The ray passes through a parallel sided air cell in water. Note refraction away from the normal at the entering point, and towards the normal at the point of emergence.

Fig. 9. Change of Focal Length of a Lens, caused by difference in surrounding medium. Above: A double-convex (convergent) glass lens in air. Focal length is about 15 cm. Below: An identical lens in water. Focal length is increased to about 56 cm.

Fig. 10. "Power" of a Lens, as determined by material of lens and surrounding medium. Above: Double convex glass lens in air, a positive lens; converges a bundle of parallel rays. Below: Double convex hollow (air) lens in water, a negative lens; diverges a bundle of parallel rays.

Fig. 11. Continuation of Fig. 10. Above: Double concave glass lens in air, a negative lens; diverges a bundle of parallel rays. Below: Double concave hollow (air) lens in water, a positive lens; converges a bundle of parallel rays; note spherical aberration, shown by increasing divergence beyond the focal point of rays that have passed through the lens at increasing distances from the center.

Fig. 12. Refraction of a Ray in a Medium of Varying Density. The ray enters the Trough at the left and passes upward. The trough contains calcium chloride solution the density of which gradually diminishes with distance from the bottom. The ray is curved downwardly as it passes upward. This experiment is the analog of atmospheric refraction at sunset.



85580, illuminated (unretouched halftone)

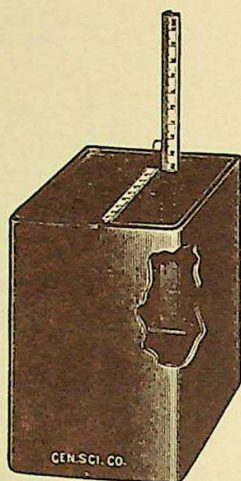
85580 LUMIROD, Cenco, for demonstrating the phenomena of total reflection of light in a spectacular and impressive manner with material of such low cost, as compared to fused quartz, that teachers need no longer omit the demonstration because of the expense involved. The cost of the Lumirod is so low that the effectiveness of the demonstration can be increased without difficulty, through the use of two Lumirods, one being held stationary on a stand and the other moved about with one end against that of the fixed Lumirod. Increased beauty and effectiveness are secured by interposing colored glass plates, such as those of No. 87360 Color Filters, in the beam of light which causes the Lumirod to be suffused with colored light.

The Lumirod consists of a flat spiral of two complete turns made from a rod of clear methyl methacrylate having optical properties—transmission and refractive index—not far from those of quartz. At the center of the spiral the rod is bent at right angles. When one end of the rod is illuminated in the direction of the axis of the rod by an intense beam of light, such as is secured from Nos. 85264 or 86605 Illuminators, the light is confined largely within the rod and is emitted from the other end as a bright beam. Because of the high refractive index of the material and its high transmissiveness, no light can escape from the rod, except that which is scattered by minute particles or bubbles within the material, and very little is absorbed. If a second Lumirod is placed end-to-end with the first, it too, becomes brightly illuminated along its entire length. Dimensions: length of rod, approximately 48 inches; diameter of rod, $\frac{1}{2}$ inch; diameter of spiral, 8 inches. Lumirod only, without illuminator, support or colored glass plates..... **Each \$3.75**

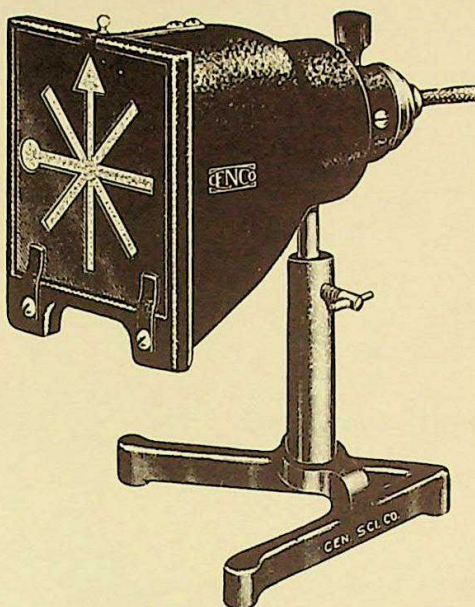
10% discount in lots of 6

LIGHT
Refraction

PRICES CHANGED
WRITE FOR QUOTATION



85600



85607

- 85600 REFRACTION APPARATUS, Minor**, for studying refraction at a plane surface and the caustic curve; and for measuring the index of refraction of water. The apparatus consists of a T-shaped metal frame on which are supported two waterproof millimeter scales and a small white "object." The metal frame is supported on the rim of a rectangular box, blackened inside, for holding water. The "object" is supported about 10 cm beneath the water surface; the horizontal millimeter scale is in the plane of the surface; and the vertical scale extends upwards in line with the "object" perpendicular to the surface. The arrangement is clearly shown in the cut.

In use, the reflected image of the vertical scale appears inverted, and extending downward from the water surface; and the small white strip which comprises the object appears to lie against the face of this reflected image. Readings are taken of the apparent position of the object on the vertical scale image and the corresponding reading on the horizontal scale of the point at which the line of sight crosses the latter. From these readings, and the actual distance of the object beneath the surface, the caustic curve may be computed and plotted, and the index of refraction of water found. The experiment is fully discussed in Exp. 92 of Minor's *Physical Measurements*.....

10% discount in lots of 6

Each \$17.00

For experiments employing this or similar apparatus, see S. E. P. L32ab. See list of Manual References, page 1000.

- 85607 OPTICAL OBJECT BOX, Cenco**, for all laboratory or demonstration experiments requiring a convenient "object" for image formation with mirrors and lenses. It consists of a No. 87664 Optical Object mounted on a support rod 10 mm in diameter and 15 cm long which telescopes into a No. 72202 Stand Tube Support.

The images formed are sufficiently bright for observation and measurement without having the laboratory dark. If the pattern plate is removed, there is provided a 10 cm by 10 cm source of light of approximately uniform intensity, which forms an excellent background for viewing transparencies, projection slides, etc.

This apparatus is especially suited, when used with an optical bench, as suggested, and with suitable lenses and spherical mirrors, for determining focal lengths, character of images formed, and sizes of object and images as related to their respective distances from lens or mirror. Other uses will readily suggest themselves to the instructor.

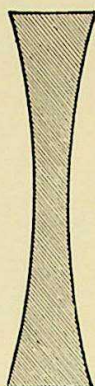
Complete with 115-volt frosted bulb and special support stand, but without optical benches or other accessories mentioned above.....

10% discount in lots of 6

Each 15.75

LIGHT
Lenses

85645



85650



85655

85645 LENSES, Double Convex, ground edges, first quality.

No.	1	2	3	4	5	6	7	8	10	11	12
Diam., cm	3.75	3.75	3.75	3.75	3.75	5	5	7.5	10	10	12.5
Focus, cm	5	10	15	20	30	12.5	50	17.5	25	50	35
No. per Cenco Pkg.	12	24	24	24	24	12	12	12	6	6	6
Each	\$1.10	.55	.52	.50	.50	.85	.80	1.95	2.50	2.40	4.70

10% discount for Cenco Packages

85650 LENSES, Double Concave, ground edges, first quality.

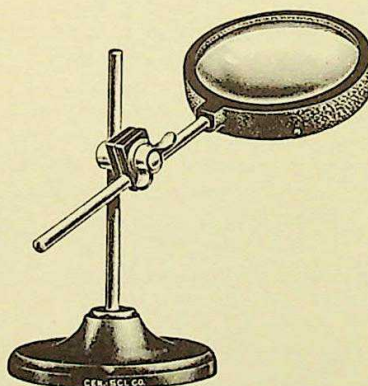
No.	A	B	C	D	E
Diameter, cm	3.75	3.75	3.75	5	7.5
Focus, cm	10	15	20	20	20
No. per Cenco Package	24	24	24	12	12
Each	.60	.60	.60	.95	2.20

10% discount for Cenco Packages

85655 LENSES, Plano-convex, commonly used as condensing lenses in projection lanterns.

No.	A	B	C	D	E
Diameter, inches	4	4½	4½	4½	5
Focus, inches	7	6½	7½	10	9
Each	2.45	2.45	2.45	2.45	2.75

10% discount in lots of 6



85660

85660 LENS, Mounted, Double Convex, Adjustable Stand, for demonstrations and experiments in optics or for use as a large diameter magnifier to facilitate laboratory work with very small objects and fine materials like quartz fibers. The wide aperture permits the use of both eyes, with enhancement of the three-dimensional or relief effect.

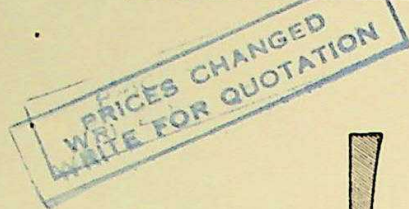
The double-convex lens is 12.5 cm in diameter with a focal length of approximately 35 cm. It is securely mounted in a heavy metal frame with black wrinkle finish. The lens and its mounting are attached to a vertical support by means of a rod and adjustable clamp. It can be clamped in exactly the position for best magnification and most convenient use. As ordinarily used, a magnification of 2 to 2.5 diameters is secured.

Each 13.00

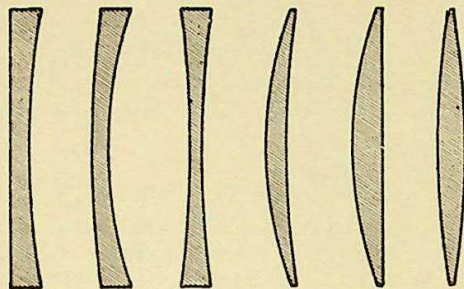
10% discount in lots of 6

85665 LENS, Mounted, Plano-Convex, Adjustable Stand, same as No. 85660 Lens, but with a plano-convex lens, 12.5 cm in diameter with a focal length of approximately 23 cm, instead of the double-convex lens. When used as a magnifier, the field is not quite as flat as that of No. 85660 Lens. The magnification as ordinarily used is about 2.5 diameters.**Each 11.00**

10% discount in lots of 6



85670



85675



85690



85705

LIGHT
Lenses

85670 LENSES, in mounting to fit No. 85905 Support, for use on optical bench No. 85755.

No.	A	B	C	D
Kind	Double convex	Double convex	Double concave	Double concave
Focal length, cm	20	10	20	10
Each	\$1.95	2.25	1.80	2.60

10% discount in lots of 6

85675 LENSES, Demonstration Set, consists of six lenses with ground edges, plano-concave, convexo-concave, double concave, concavo-convex, plano-convex, double convex, each 3.75 cm. in diameter, in box.....Per set 3.40

5% discount in lots of 6

85680 LENSES, Demonstration Set, set of six lenses as above listed, but 5 cm in diameter, in box.....Per set 6.15

10% discount in lots of 6

85685 LENSES, Demonstration Set. Ten lenses 3.75 cm in diameter, consisting of cylindrical convex, cylindrical concave, spherocylindrical convex and plano-prismatic, in addition to the six lenses of set No. 85675, complete in box.....Per set 11.50

10% discount in lots of 6

85690 LENS, Fresnel's, a highly polished glass casting, 7.5 cm in diameter. Shows construction of lenses used in lighthouses, semaphores, etc., and the advantages of the use of same.....Each .60

10% discount in lots of 12

85700 LENSES, Concave and Convex, consisting of a double convex lens 3.75 cm in diameter of 20 cm focal length and a double concave lens of the same diameter and focal length. Having the same curvature, these fit together quite well and can be used to show the neutralizing effect of such a combination of lenses on a parallel beam of light.....Per set 1.00

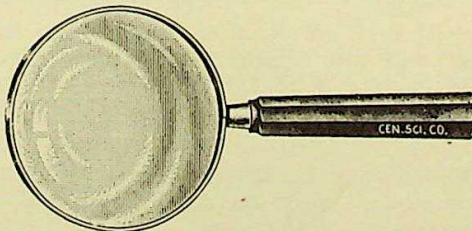
10% discount in lots of 12 sets

85705 LENS, Achromatic. A high grade lens, consisting of a plano-concave flint glass lens and a double convex crown glass lens, perfectly fitted and accurately ground. Diameter 5 cm, focus 20 cm.....Each 4.65

10% discount in lots of 6



60120



60410

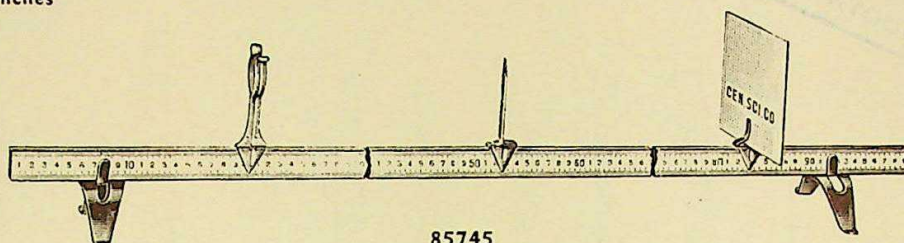
60120 MAGNIFIER, Linen Tester, for use in counting the number of threads per linear inch in fabrics, and in elementary biological work. It consists of a 13-mm lens mounted in a folding, brass frame, the lower arm of which is cut out to cover a 1/2-inch square area of fabric. Magnification, about 10 diameters.....Each 1.90

10% discount in lots of 6

60410 LENSES, Reading Glasses, with nickeled rim and ferrule, and with black wooden handle.

No.	A	B	C	D
Diameter of lens, inches.....	2	2 1/2	3	4
Focus, inches	5	6	7	10
Each	1.30	1.45	1.85	2.55

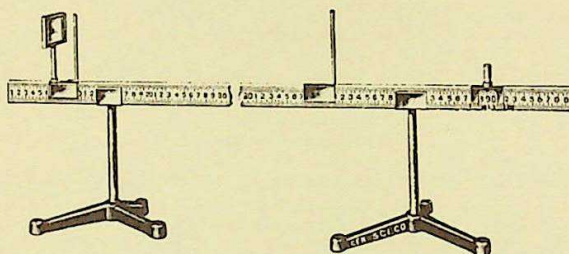
LIGHT
Optical Benches



85745

- 85745 OPTICAL BENCH, Elementary Form**, a very useful bench for elementary work, designed for performing the various simple experiments which occur in most manuals of elementary physics. Includes No. 73115 Meter Stick, No. 85850 Metal Support, No. 85900A Lens Support, No. 85950 Object and Marker, No. 85965 Screen and No. 85970 Screen Support.....Each \$1.65
10% discount in lots of 12

- 85750 OPTICAL BENCH, Elementary.** Same as No. 85745 Bench, but with No. 85855 Metal Supports in place of No. 85850 Metal Supports.....Each 2.75
10% discount in lots of 6



85755

- 85755 OPTICAL BENCH, Student's**, designed to meet the requirements for the various experiments with lenses, mirrors, and diffraction gratings that occur in most manuals of elementary college physics. When used with No. 85435 Mirror, No. 85670 Lenses, No. 85905 Mirror or Lens Support, No. 86255 Grating Holder, No. 86250 Diffraction Grating, and No. 86260A Scale and Slit it is extremely flexible, so that it may be employed in the following experiments:
1. Image formation by spherical mirrors, and measurement of focal length of a concave mirror.
 2. Image formation by lenses; magnifying power and focal length measurements.
 3. Studies of optical instruments: microscopes, simple and compound telescopes, Galilean and astronomical.
 4. Measurement of wavelength of light by means of a diffraction grating.

The experiments enumerated will occupy about six laboratory periods.

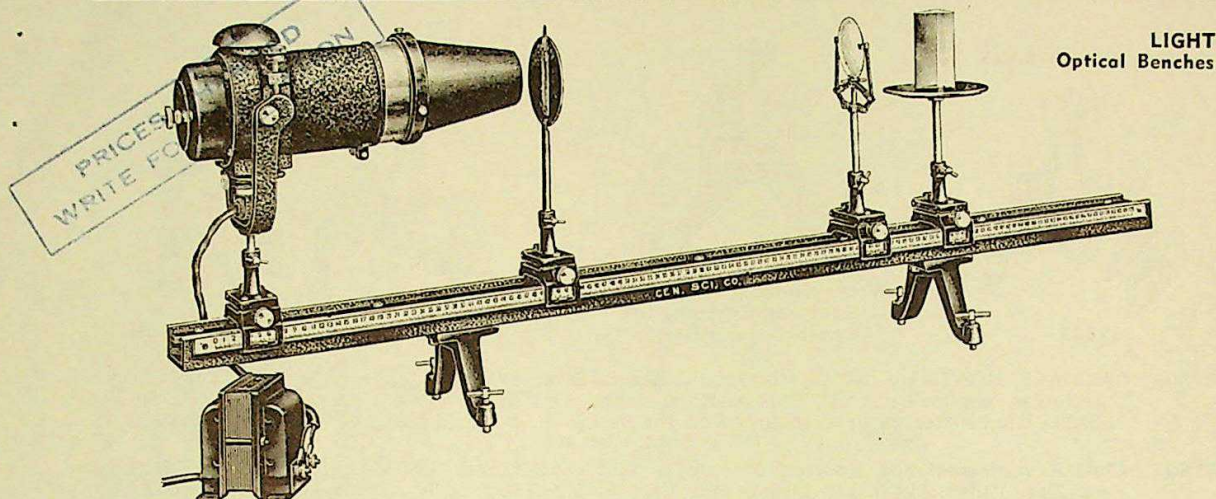
The Optical Bench, as supplied, comprises the following parts: 2 No. 85860 Tripod Supports; 1 object wire with adjustable mirror background; 1 image finder, for locating images by the parallax method; 1 No. 85905 Lens or Mirror Support. The meter stick is not supplied, since this is a stock item in every laboratory.

In addition to the accessories listed above, the following will be found useful: No. 72677 Vernier Calipers and No. 72690 Caliper Jaw Attachments, for measuring the thickness of concave and other lenses; No. 85970 Screen Support, for holding screens or millimeter scales. Without meter stick.....Each 9.00
10% discount in lots of 6



73115

- 73115 SCALE, METER STICK, Maple.** Both edges of one face are graduated in decimeters, centimeters and millimeters; one edge of the other face in inches and eighths.....Each .48
10% discount for Cenco Package of 24



LIGHT
Optical Benches

85801 Optical Bench, with accessories for spectrum projection, including No. 86605 Illuminator, No. 86140 Slit and No. 85510 Lucite Prism

85801 OPTICAL BENCH, Cenco, Lathe Bed Type (Patent No. 1,849,305), for the lecture demonstration and for laboratory work in optics, sound, and other branches of physics. Speaking broadly, there is probably no more generally useful item of apparatus than a good optical bench. In fact, a well designed optical bench with suitable accessories suffices for practically all the laboratory experiments in the optics courses. In addition, again with properly designed accessories, it is applicable to numerous experiments in other branches of physics, particularly those designed for demonstration by projection.

The Cenco Optical Bench embodies all the features that make for ease of operation and accuracy of measurement. It consists of a steel bed with two rails accurately matched on which the carriages ride. A scale 125 cm long graduated in mm permits the setting of a carriage to within 0.2 mm. The bed is bolted to two pairs of supporting legs provided with levelling screws and finished with gloss-black enamel. Between the rails is secured a strip of steel to which the carriages are clamped.

The carriages have a V-groove on one side and a plane on the other which rest on the rails. Above the window with the index mark on the carriage is a knurled screw by means of which the carriage may be firmly secured to the bed and as easily unclamped for adjustment. The upper part of the carriage with its sleeve clamp for a standard 10 mm rod is hinged at the back to the lower part so that it may be tilted toward the rear where it is held by a stop with the rod in a horizontal position. The entire carriage can be lifted off the bench and set on the table, supporting any device which it carries in a vertical position.

In experiments in which greater length than 125 cm is needed or in which a source of light may be required at some distance from the optical bench, No 85810 Auxiliary Bench without graduated scale is useful.

We have designed a large number of accessory devices which fit the carriages of the Cenco Optical Bench. With them it is possible to assemble the apparatus for the following purposes:

- | | |
|--|--|
| 1. Photometry. | 9. Lantern slide projection. |
| 2. Color demonstrations. | 10. Projection of stream lines around various obstacles. |
| 3. Projection of Newton's Rings. | 11. Projection of Lissajous' figures. |
| 4. Projection of diffraction fringes. | 12. Projection of motion of a vibrating string. |
| 5. Measurements with diffraction slits of various kinds. | 13. Precision measurements of bending of beams under load. |
| 6. Polarization experiments. | |
| 7. Experiments in photo-elasticity. | |
| 8. Shadow projections of electroscopes, projection cells, etc. | |

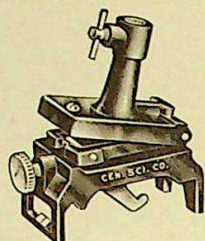
As described, with three carriages, but **without** No. 85802 Carriage or accessories....**Each \$37.50**
10% discount in lots of 3

For experiments employing this or similar apparatus, see I. & M. Exp. 76, p. 257; Ham. Exp. 508, p. 120; White Exp. 63, p. 321, Exp. 65, p. 331; Rich Exp. 55, p. 190, Exp. 56, p. 193; Z. & E. Exp. 5, p. 85; T. W. & H. Exp. 48, p. 134; Min. Exp. 97, p. 130, Exp. 98, p. 134; D.C.M. Exp. 103, p. 216; M. G. & E. Exp. 47, p. 183, Exp. 48, p. 185; M. & W. Exp. 2, p. 8, Exp. 7, p. 21; S. E. P. L11b, L12b, L21b, L22b, L23b. See list of Manual References, page 1000.

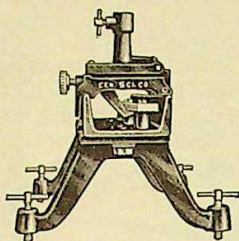
85802 CARRIAGE, Hinged, for Cenco Optical Bench. Holds all accessories provided with 10 mm support rod. Upper part is hinged to tilt through 90°, facilitating quick removal of lenses from, or their insertion in, the path of light. A strong spring latch holds the upper part rigidly against lower. The carriage is easily clamped to the Optical Bench and when removed may be stood on the table. Finished in baked black wrinkle enamel. (Illustrated on next page).....**Each 3.80**

10% discount in lots of 6

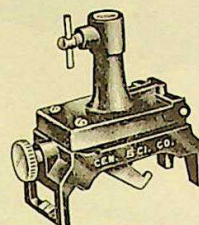
LIGHT
Auxiliary Optical Bench



85802



View showing method of
clamping Carriage to
Cenco Optical Bench



85804



85805

85804 CARRIAGE, Non-Tilting, for Cenco Optical Bench. Same as No. 85802, but upper part is screwed to lower, and will not tilt. This carriage should be used when a heavy object, such as No. 86605 Illuminator, is to be mounted on the bench. With baked black wrinkle finish. **Each \$3.75**
10% discount in lots of 6

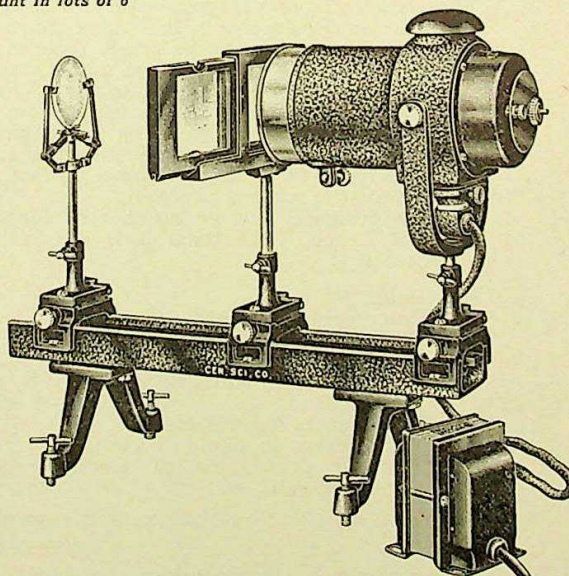
85805 CLAMP, Horizontal Rod Adapter, for use in Nos. 85802 and 85804 Optical Bench Carriages or Nos. 72230 and 72322 Bench Rod Clamps for clamping No. 86595 Universal Holder for Incandescent Lamps, No. 86665 Eye Shades, or similar optical bench or photometer accessories with horizontal rods. Consists of a T-casting, finished in baked black japan, with a 13 mm hole drilled through the center of the horizontal member, and a 10 mm ($\frac{3}{8}$ inch) nickel-plated rod attached to the vertical member. A nickel-plated T-screw is provided to clamp the horizontal rods in place. Length of rod, 75 mm. **Each 2.75**
10% discount in lots of 6

85806 ROD, Offset, so bent that the part used for supporting apparatus on the optical bench is displaced about 14 cm from the part which fits the carriage. By turning the rod in its supporting clamp, its upper end can be fixed at any desired distance from the central axis, up to 14 cm. Diameter, 10 mm ($\frac{3}{8}$ inch). **Each 2.75**
10% discount in lots of 6

85809 TABLE TOP, Cenco, of $\frac{3}{4}$ -inch, waterproof plywood, 54 inches long by 24 inches wide, with black finish. Three toggle action clamps are attached to the bottom to permit mounting on a No. 74790 Rotating Platform. The table may then be rotated readily to permit every observer in a lecture room to see a demonstration from all sides. Complete with clamps but **without** rotating platform. **Each 22.50**
10% discount in lots of 6

DIAMETERS OF SUPPORT RODS

Support rods for Cenco optical bench accessories are made from $\frac{3}{8}$ inch diameter stock; clamps are drilled to take $\frac{3}{8}$ inch (approximately 10 mm) diameter support rods.

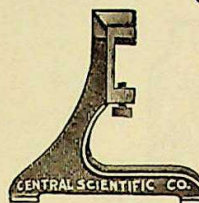


85810 shown in use with No. 86605 Illuminator, No. 86115 Lantern Slide Holder, No. 85645 Lens, No. 72288 Lens Holder and 3 No. 85804 Carriages.

85810 OPTICAL BENCH, Cenco, Auxiliary, (Patent No. 1,849,305), for use either in combination with No. 85801 Optical Bench, or separately for supporting projection accessories. The Auxiliary Bench should be used with No. 85801 Optical Bench, when experiments are to be performed in which the projected beam of light is to be reflected or refracted at an angle to its initial path. This bench is similar to No. 85801, but has no millimeter scale, and its length is only 51 cm. The cut shows it in use with No. 86605 Illuminator, No. 86115 Lantern Slide Carrier, and No. 85645 Lens, the assembly constituting a convenient slide projector. This is convenient also as a general demonstration projector. **Without accessories. Each 20.25**
10% discount in lots of 6

LIGHT
Optical Bench Supports

85850



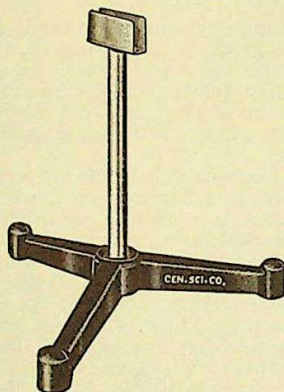
85855

- 85850 SUPPORTS, Metal**, for elementary optical bench. These sturdy supports are stamped out of steel and finished in glossy black, baked enamel. A pair holds a meter stick as shown in illustration of No. 85745. **Per pair \$0.50**

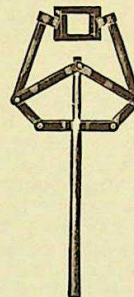
10% discount in lots of 12 pairs

- 85855 SUPPORTS, Metal**, for elementary optical bench. Designed for those who desire a more substantial support than the ordinary wooden blocks. These supports clamp to the meter stick, holding it rigidly in position so that the location of screens, lens supports, etc., may be changed without danger of overturning the bench. Height of top of meter stick above table, 10 cm. **Per pair 1.70**

10% discount in lots of 12 pairs



85860



72288 in use

- 85860 SUPPORTS, Tripod**, for assembling optical bench. Two of these supports and one No. 73115 Meter Stick are used, as shown in the illustration under No. 85755. Their height is such that when they are used on the laboratory table, the observer may sit erect in performing the usual experiments with lenses and mirrors. Supports lower than these require the observer to assume an uncomfortable stooping position which soon results in fatigue. The tripod base has legs 11 cm long and the 11 mm rod has a "U" shaped clip at the top to hold the meter stick. As described **Each 2.25**

10% discount in lots of 12

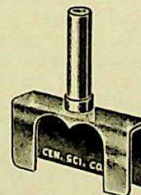
- 72288 LENS HOLDER**, for lenses 2.5 to 10 cm in diameter. Mounted on a $\frac{3}{8}$ inch rod to fit Nos. 85802 and 85804 Carriages **Each 2.95**



85900A



85900B



85905

- 85900 LENS or MIRROR SUPPORTS**, of metal, to slide on a meter stick.

No.	A	B
For mirror or lens of diameter, cm.....	4	7.5
Each	.18	.25

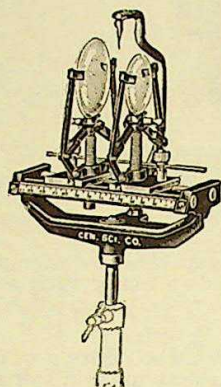
10% discount for Cenco Packages of 50

- 85905 LENS or MIRROR SUPPORT**, as used on No. 85755 Optical Bench. Nos. 85435 Mirror and 85670 Lenses fit this support. **Each .60**

10% discount in lots of 12

Physical Supports for Assembling Single and Double Rod Optical Benches, See Pages 1006 to 1010.

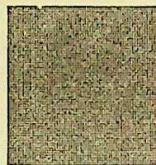
LIGHT Nodal Slide



85910 shown in use



85950



19965A



85955

- 85910 NODAL SLIDE, Cenco-Minor**, for finding the nodal points of thick lenses or of lens combinations. The nodal points are a pair of points on the axis of a system of lenses such that if an entering ray passes through one of the points, the emerging ray appears to come from the other point on a line parallel to the entering ray. If the image of a distant object, i.e. an image formed after refraction of a beam of parallel rays, is formed on a screen by a refracting system, the second nodal point has a distinctive property relative to the image which makes possible an experimental determination of its location. The property is that if the system is slightly rotated about an axis through this point, there will be no shift in the position of the image.

The Cenco-Minor Nodal Slide is arranged to hold one or two lenses of which the nodal points are to be determined. It consists of a main supporting bracket with two horizontal rods; the bracket is swivelled on a 10 mm vertical support rod, by means of which the entire slide can be supported in an optical bench clamp. The bracket, in addition, carries a downwardly projecting indicating point on a bent arm. This point is in the vertical axis of rotation of the bracket. The two horizontal rods carry two slides on which are mounted two of our patented lens holders like No. 72288. These slides are independently movable, but each can be clamped to a tie rod, which constrains them to move as a unit. Their minimum separation is about 17 mm, and their range of motion is 70 mm when moving together, or 105 mm when moving individually. A millimeter scale is provided, on which the positions of the two slides are indicated. By using No. 72690 Caliper Jaw Attachments with No. 72677 Vernier Calipers, distances between proximate surfaces of thick lenses held in the lens holders on the Nodal Slide can readily be measured.

In use, two methods of procedure may be adopted. Assume that the nodal points of a combination of two lenses are to be found. These are mounted in the lens holders at a selected distance apart. In the first procedure, the Nodal Slide is mounted in one carriage of an optical bench, and No. 86010 Hooded Screen in another, with the white surface of the latter towards the lenses. Some distant luminous object (like No. 87664 Optical Object) is then used as a source, and an image is formed on the screen by the lenses. The Slide is then rotated through a small angle and the image observed. If the image shifts, the lens combination is shifted on the slide, the image refocused, and the test repeated. When there is no shifting of the image as the Slide is rotated, one nodal point is in the axis of rotation. The entire slide is now turned through 180°, and the other nodal point is found in the same manner.

The other method is that of autocollimation, to form an image from parallel rays. No. 86030 Object and Screen is used, with a light behind the perforated arrow. A plane mirror is placed behind the lens combination, reflecting light from the object back through the lenses. With proper adjustment a clear inverted image appears on the screen adjacent to the object. From this point on the procedure is identical with the first. **Without lenses or other accessories mentioned Each \$62.00**

5% discount in lots of 3

For experiments employing this or similar apparatus, see M. & W. Exp. 8, p. 23; T. W. & H. Exp. 48, p. 134; Min. Exp. 98, p. 134; Tay Exp. 1, p. 18; S. E. P. L23b. See list of Manual References, page 1000.

- 85950 OBJECT AND MARKER.** Of metal, to slide on meter stick..... **Each .27**

10% discount for Cenco Package of 50

- 19965A SCREEN, Object.** Of wire gauze, 10 cm square, for use in front of a source of light as an object. (For support, see No. 85970)..... **Each .06**

20% discount for Cenco Package of 100

- 85955 SCREEN, Object.** For use on No. 85970 Screen Support as an object in experiments on focal length of lenses, etc. The image of the wire screen may readily be brought into focus since it is sharply defined, and the location of a hole punched off-center in the screen makes it easy to determine the character of the image, whether erect or inverted. Mounted on a heavy cardboard 7.5x12.5 cm, one side of which is black, the other white..... **Each .40**

10% discount for Cenco Package of 25



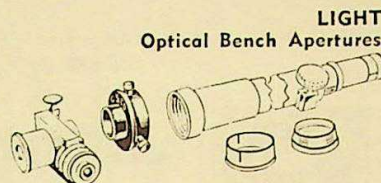
86034



86036



86038



86090

LIGHT

Optical Bench Apertures

- 86034 OBJECT SCREENS, Mounted, Cenco-Minor, Set of Two**, for use with No. 86030 to serve as objects in experiments on image formation and resolving power of lenses. One screen is very fine mesh, the other somewhat coarser. Per set \$4.75

10% discount in lots of 6

- 86036 OBJECT SCREENS, with Slits, Cenco-Minor, Set of Two**, for use in No. 86030 Object Holder in experiments with No. 86250 Diffraction Grating. (See Minor, *Physical Measurements*, Part 2, 1947, p. 155.) In both screens the two slits are horizontal and parallel, but on opposite sides of the vertical line. In one screen the slits are 1 cm apart, in the other 2 cm. Length of slits, about 12 mm; width, about 0.8 mm. Dimensions of screen, 3.5 cm by 5 cm. Per set 2.35

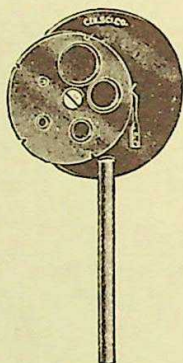
10% discount in lots of 6

- 86038 OBJECT and IMAGE SCREEN, Cenco-Minor**, for use in No. 86030 Object Holder in determining focal length of concave mirrors, and of converging lenses by the auto-collimation method. The object is in the shape of an arrow cut in a black plate. It is separated from the white image screen by a black metal partition. Each 5.25

10% discount in lots of 6

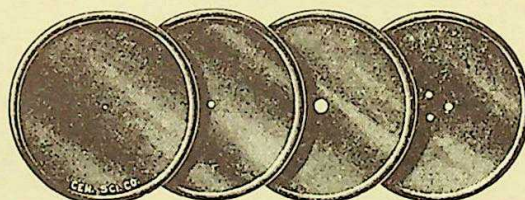
- 86090 ADAPTER**, for attaching No. 65570 Filar Micrometer Eyepiece in place of the objective of a telescope. Will fit telescope tubes from 25 mm to 32 mm diameter. For measuring focal length of the telescope eyepiece. See Minor, *Physical Measurements*, Part 2, 1947, p. 139. Each 6.35

10% discount in lots of 6

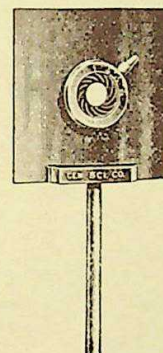


86100

DIAMETERS OF SUPPORT RODS
Support rods for Cenco optical bench accessories are made from $\frac{3}{8}$ inch diameter stock; clamps are drilled to take $\frac{3}{8}$ inch (approximately 10 mm) diameter support rods.



86102



86105

- 86100 APERTURE, Circular.** Five apertures, ranging from 3 to 23 mm in diameter, mounted so that any one can be clamped in position at the center of a circular screen, which is mounted on a rod to fit No. 72322 Clamp. Each 15.50

10% discount in lots of 6

- 86102 APERTURES, Pinhole, Cenco**, for demonstrating the nature of images produced by small apertures. See "Demonstration Lectures in Physics," Series J, Lecture No. 1. They demonstrate rectilinear propagation of light, and show how, in a pinhole camera, definition is improved as the size of the aperture is decreased. The diaphragm with three apertures produces three individual images.

The apertures consist of four perforated metal disks, nicely finished in black, to fit into the end of the housing of either No. 85261 or No. 85262 Illuminators when the condensing lenses are removed. The perforations in three of the disks are 0.5 mm, 2 mm, and 5 mm in diameter, respectively. The fourth disk has three apertures on the vertices of a small equilateral triangle.

In use, either the illuminator may be used on its own support and the images thrown on any convenient screen, or the illuminator may be supported by a carriage on a No. 85801 Optical Bench with a No. 86005 Ground Glass Screen to receive the image. A No. 85809 Rotating Table Top will be found to be extremely convenient as a rotating support for the optical bench to permit the entire audience to view the apparatus and projection from all angles. Set of four apertures, only, without illuminators or other accessory equipment. Per set 3.50

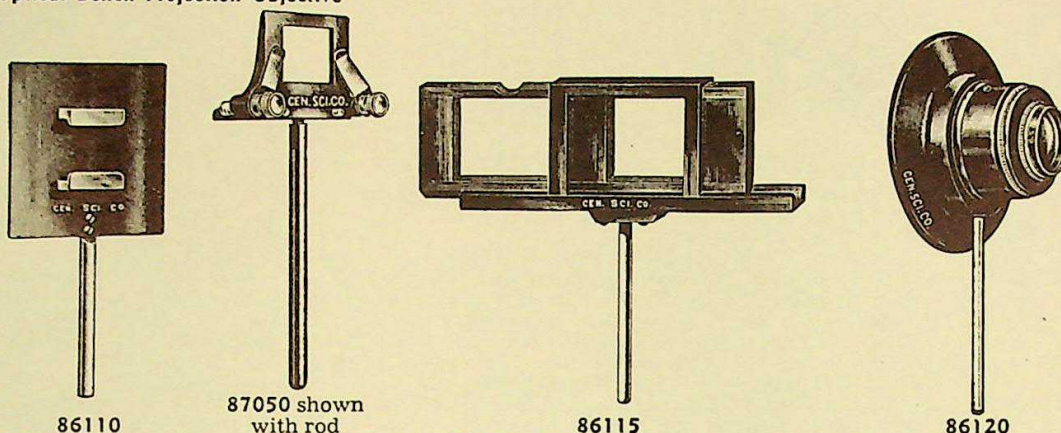
10% discount in lots of 6

- 86105 IRIS DIAPHRAGM, Mounted**, for use in projection experiments. It consists of a black metal light shield at the center of which is mounted the iris diaphragm of precision grade adjustable between the limits of 1 mm and 33 mm in diameter. A scale on the rim of the diaphragm indicates the diameter of the opening in mm. The light shield is so supported on a 10 mm rod that the plane of the diaphragm contains the axis of the rod so that the index mark on the supporting optical bench carriage correctly shows the location of the diaphragm. An iris diaphragm of this type is an essential part of many experimental arrangements on the optical bench. Each 12.00

10% discount in lots of 6

LIGHT

Optical Bench Projection Objective



- 86110 GRATING HOLDER**, for use on No. 85801 Optical Bench in spectrum projection and color demonstration. Consists of a black metal light shield on a 10 mm support rod, with two slides spaced to hold a diffraction grating on a mount 50 mm wide. Suitable for holding Replica Grating No. 86841. **Each \$4.50**

10% discount in lots of 6

- 87050 GRATING HOLDER**, for supporting mirrors or gratings. Consists of a cast mounting with square aperture about 30x35 mm and spring clips to support objects up to 50x50 mm. A threaded hole is provided for a No. 72162 Rod. **Without rod. Each 4.60**

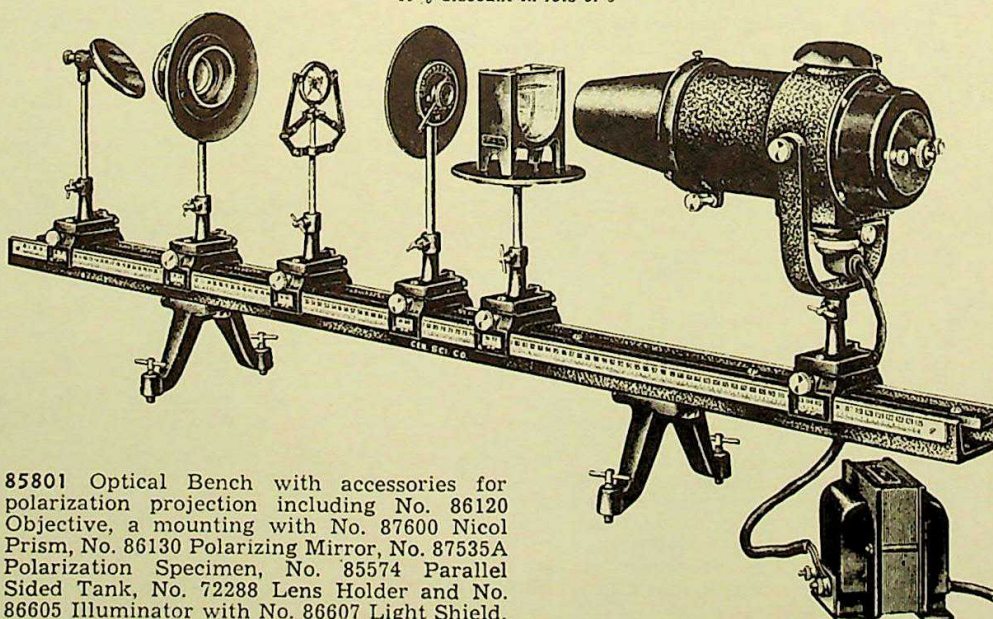
- 86115 LANTERN SLIDE HOLDER**, mounted on 10 mm rod to fit optical bench carriage. Enables projection with No. 86605 Illuminator and No. 86120 Objective of standard lantern slides. The parts enumerated, when mounted on No. 85810 Bench, make an excellent lecture table projector. **Each 15.00**

10% discount in lots of 6

- 86120 PROJECTION OBJECTIVE, Shielded.** Mounted on a 10 mm rod, to fit the carriages on the No. 85801 Cenco Optical Bench. For all projection demonstrations, including lantern slide projection with No. 86115 Holder. No. A is a short focus objective, for producing relatively large images, at short screen distances, for example, on a translucent screen near the lecture table. No. B is a long focus objective, with a larger aperture for projecting to greater screen distances. Both objectives are made of the best colorless optical glass, with minimum obtainable chromatic and spherical aberrations, and produce an image having excellent flatness of field. Each has a light shield around it to prevent stray light from reaching the screen.

No.	A	B
Diameter, mm	42	64
Equivalent focus, cm	20	30
Each	39.00	46.50

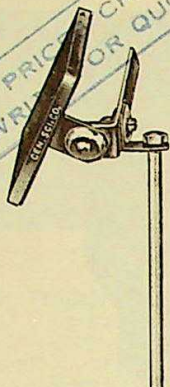
10% discount in lots of 5



85801 Optical Bench with accessories for polarization projection including No. 86120 Objective, a mounting with No. 87600 Nicol Prism, No. 86130 Polarizing Mirror, No. 87535A Polarization Specimen, No. 85574 Parallel Sided Tank, No. 72288 Lens Holder and No. 86605 Illuminator with No. 86607 Light Shield.

LIGHT

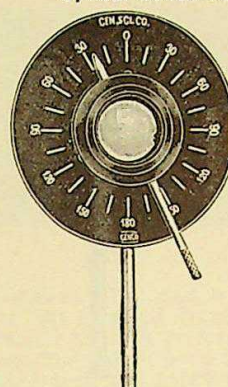
Optical Bench Polarizers



86130

DIAMETERS OF SUPPORT RODS

Support rods for Cenco optical bench accessories are made from $\frac{3}{8}$ inch diameter stock; clamps are drilled to take $\frac{3}{8}$ inch (approximately 10 mm) diameter support rods.



86136

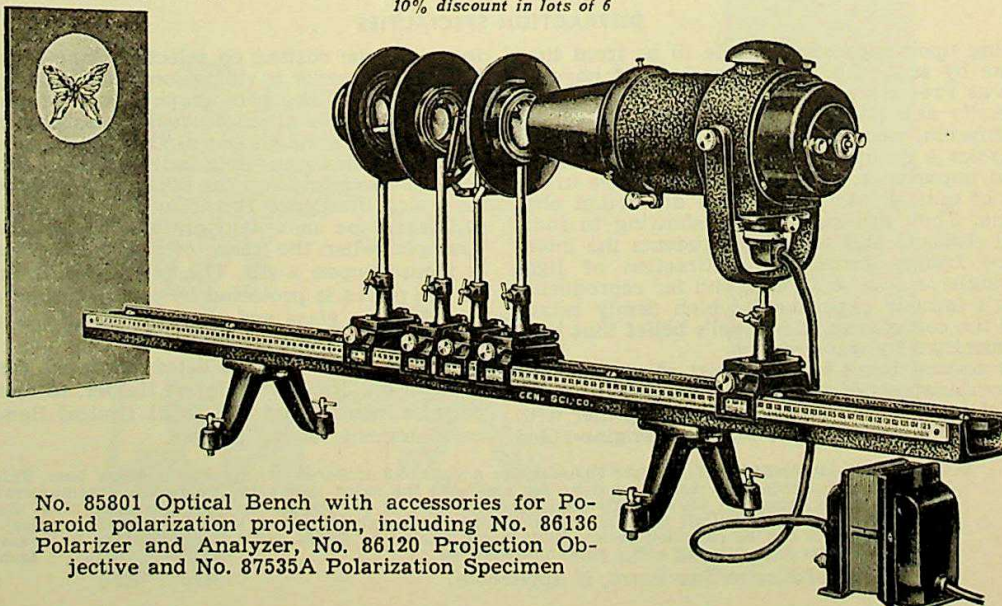
- 86130 POLARIZING MIRROR**, for use on No. 85801 Cenco Optical Bench or as a separate unit for producing a beam of polarized light. Consists of a black mirror, mounted on a 10 mm rod with a friction hinge and swivel. This mounting permits its being adjusted to the angle of maximum polarization, and then to be rotated about a horizontal axis. By using two of these mirrors, one of them mounted on No. 85810 Auxiliary Bench, or other suitable support, and used as an analyzer, the various demonstrations in polarization by reflection may be performed.....
.....Each \$8.00

10% discount in lots of 6

- 86136 POLARIZER OR ANALYZER, Optical Bench, Cenco**, for experiments and demonstrations with polarized light. The availability of an efficient polarizing medium, in the form of No. 87601A Polaroid Disks, has made possible very effective demonstrations with polarized light on a scale which formerly would have required exceedingly expensive Nicol prisms and the associated projection systems.

This unit consists of a mounting to which is fitted a 45 mm Polaroid Disk, which can be rotated on a horizontal axis. The mounting fits into a light shield, with angular graduations at 15° intervals numbered at every 30° each side of 0° to 180° . A pointer on the mounting shows the setting on this scale, and a handle protruding over the edge of the light shield permits easy setting at any desired angle. The mounting and shield are secured to a standard 10 mm rod, 15 cm long. The unit is thus suitable for use in any standard optical bench carriage for either single-rod or double-rod benches, or for No. 85801 Cenco Optical Bench. Since the unit serves as either polarizer or analyzer, a pair of them constitutes the essential equipment for all demonstrations with polarized light. The large aperture simplifies optical arrangements. The usual experiments with parallel light to show strains in glass and to demonstrate experimental photo-elasticity are easily performed. Doubly-refracting crystals and crystal structures may be shown in either parallel or convergent light with comparatively simple adjustments in the optical system. Especially effective demonstrations can be made with a set of No. 87535 Polarization Specimens. One of the units, with No. 87520 Polarization Tube, permits an effective demonstration of the rotation of the plane of polarization by a sugar solution. Complete with Polaroid disk.....
.....Each 24.00

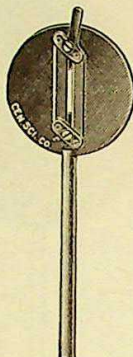
10% discount in lots of 6



No. 85801 Optical Bench with accessories for Polaroid polarization projection, including No. 86136 Polarizer and Analyzer, No. 86120 Projection Objective and No. 87535A Polarization Specimen

LIGHT

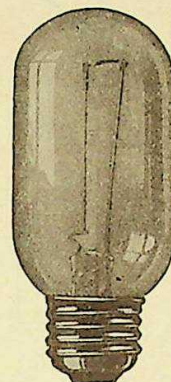
Optical Bench Slits



86140



86155



86615

- 86140 SLIT, Vertical, Adjustable.** By an ingenious parallelogram arrangement, the slit can be adjusted easily to the desired width by moving the lever to one side. The length is adjusted by vertical jaws with knobs which slide in grooves. Maximum length of slit, 25 mm; maximum width, 6 mm. Mounted on rod to fit No. 72322 ClampsEach \$13.75

10% discount in lots of 6

For experiments employing this or similar apparatus, see T. W. & H. Exp. 50, p. 140; Tay. Exp. 3, p. 42. See list of Manual References, page 1000.

- 86141 SLIT, Vertical, Precision Adjustable,** similar to No. 86140 Slit, but of improved design. The width of the slit is adjusted by means of a sliding member with knurled adjusting screw. Parallelism of the jaws is maintained at any setting. The length of the slit is not adjustable.Each 30.00

10% discount in lots of 6

- 86152 SLIT, Fixed, Slotted Disk,** for use with No. 86975 Spectrometer or similar apparatus. Consists of a metal disk 2 3/4 inches in diameter with a slot about 15 mm long and 1 mm wide in the center. One side of the disk is white, the other black.....Each .70

10% discount in lots of 12

- 86155 SLIT, Fixed, Metal Screen,** for use in elementary physics experiments on spectrum formation through the dispersion of light from a slit source by a glass prism. Consists of a black metal sheet, 30 cm square, in which a slit of 0.3 by 15 cm is cut in the center of one edge at right angles to the edge. In use, the metal screen is bent to form a section of a cylinder so that it may be stood on the table in front of a Bunsen burner. When the student views the illuminated slit through a No. 85505 Glass Prism, he sees the characteristic spectrum of the light source.....Each 1.30

10% discount in lots of 12

DIFFRACTION SPECIALTIES

Acting upon suggestions made to us from time to time by such outstanding teachers of physical optics as Professors Henry Crew of Northwestern University and Ralph S. Minor of the University of California, we have made available to teachers of physics a group of apparatus items of fundamental importance. They are very effective in the study of optical interference and diffraction phenomena. They are suitable for showing to individual students and groups of students the interference fringes formed by diffraction of light at a single or at several slits, and for reproducing Young's famous experiment which firmly established the correctness of Fresnel's belief that light is transmitted by wave motion.

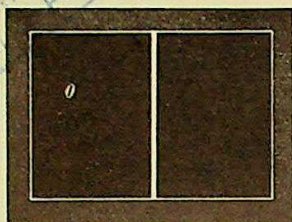
The several items listed consist of optical slits, and combinations of slits, with exceedingly sharp parallel edges and of uniform width, together with suitable light sources. The slits are engine-ruled

in an opaque coating on selected plane glass, this being far superior to rulings on a blackened photographic plate. The photographic emulsion is difficult to rule, the attempt usually resulting in slits with frayed or rough edges. The gelatin of a photographic emulsion does not readily withstand high temperatures; on the other hand, the coating on which the Cenco Precision Slits are ruled will withstand the same temperature as the glass, for example, when the image of a strong light source is focused upon a slit. The ruled surface in each of the pieces is protected by another plate of selected plane glass and the two plates are firmly bound together at the edges.

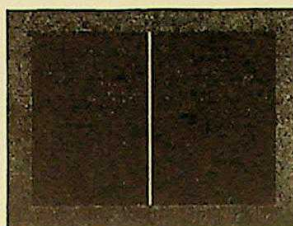
The various ruled slits listed below are designed to fit in our No. 86030 Object Holder, so that they may be mounted on No. 85801 Optical Bench for measurements of the fringes.

- 86615 LAMP, INCANDESCENT, Straight Filament,** for 6 volts, 3.5 amperes, with medium screw base. This lamp is a suitable line source of light for use with the ruled slits listed below. In a demonstration to a large group, in which individual students look at the source through the ruled slits, the lamp can be seen from all parts of the room simultaneously. When it is to be used for optical bench work, it can be mounted in No. 86585 Lamp Socket to fit No. 85802 Carriage. May be operated on 115 volts A.C. through a No. 80305 Transformer.....Each 1.60*

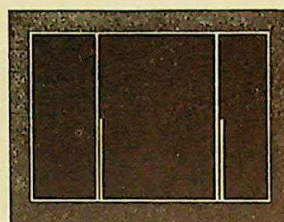
*Federal Excise Tax extra, if applicable.

LIGHT
Diffraction Slits

86200A



86200B



86205

86200 PRECISION SLITS, Cenco, for use as a line source of light for experiments in diffraction with the optical bench. In reproducing Young's experiment by projection on a small translucent screen so that a group of students can see the fringes at the same time, it is necessary to employ a stronger light than No. 86615 Straight Filament Lamp. The single precision slit here offered is especially suitable for the purpose when illuminated with No. 85262 Illuminator, the image of the source being focused on the slit. With this slit mounted in No. 86030 Object Holder, and one of the single or double slits mounted in another object holder, and a suitable projection lens (No. 85705) mounted on the optical bench, the fringes corresponding to the kind of slits used can be projected on a translucent screen placed at or near the end of the optical bench. The single slit is also useful as a source in individual student measurements if illuminated with an ordinary inside frosted incandescent lamp bulb. Each mounted slit is packed in a cardboard case.

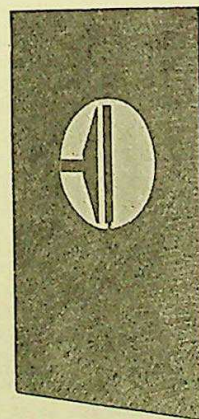
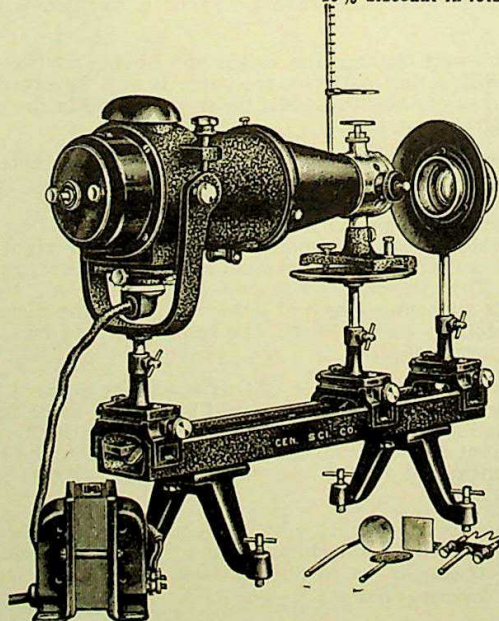
No.	A	B	C
Width, mm	0.3	0.2	0.1
Each	\$1.90	1.90	1.90

10% discount in lots of 6

86205 DIFFRACTION SLITS, Cenco. The rulings consist of two pairs of slits, one pair having about twice the separation of the other, and of slightly different width. The double ruling is carried half way across the plate, at which point one of the single slits is continued entirely across the plate. The construction permits the simultaneous comparison of the fringes produced by a double slit and by a single slit of the same width. The appearance of the diffraction pattern produced by the single and the double slits respectively is shown in excellent photographs reproduced in Michelson's "Light Waves and Their Uses" and in Taylor's "College Manual of Optics" pages 36 and 44 respectively. This pair of double slits is offered at a price which will permit purchase of a number sufficient to provide one for each student, or for a small group of students. In use, the single filament lamp is placed on the lecture table in a darkened room, and the students are told what to notice in their observations of the luminous filament through the slits.

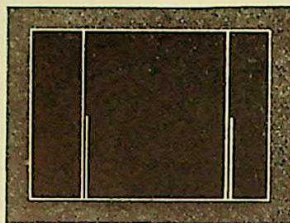
If monochromatic filters are available, an interesting additional experiment is possible. The instructor may cover the upper section of the filament with a blue, and an adjacent section with a red filter. The student in viewing the source through a double slit, sees a pronounced difference in fringe separation between the blue and the red, the red being much more widely spaced. On account of absorption of light by the filters, the observer must be within ten feet of the source to see the fringes. In cardboard case.....Each 1.90

10% discount in lots of 6

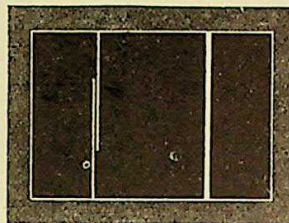


No. 85810 Auxiliary Bench
shown in use with No. 71020
Zeleny Electroscope, No. 86605
Illuminator with No. 86607
Light Shield and No. 86120
Projection Objective

LIGHT **Diffraction Slits**



86210



86220

- 86210 PRECISION SLITS, Cenco, for Laboratory Measurement.** These are similar in general design to No. 86205 listed above, but they are precision ruled, the easily measurable width and spacing so chosen as to secure a maximum number of fringes of adequate intensity. In the one pair the spacing is approximately 0.02 cm and in the other 0.08 cm. For the cover glass selected glass only is used, which permits accurate measurements to be made. A sheet of mica is supplied, from which the student can split a thin wafer, one edge of which is to be cut straight. When this is inserted between the source and one of the slits of the pair with wider spacing, a displacement of fringes is produced which is proportional to the thickness of the mica. A color filter should be used to render the light approximately monochromatic. If desired, a monochromatic flame burner, condensing lens and single ruled slit (No. 86200) may be used as the source. From the fringe shift, which may be measured with a No. 65570 Micrometer Eyepiece, the refractive index of the mica, and the wavelength of the light used, the student can determine the thickness of the mica sheet.

He may endeavor to check this with a micrometer caliper, and will be impressed by the fact that a shift of several fringes is produced by a thickness of mica of a few thousandths of a millimeter, a thickness which a micrometer caliper cannot measure with accuracy. In cardboard case.....

Each \$4.00

10% discount in lots of 6

- 86215 PRECISION SLITS, Cenco, for determining the thickness of a thin transparent lamina from the shift of the fringes.** These fixed slits are similar to No. 86210, except that one is covered for about 5 mm with a very thin flake of mica. Its use is completely described in Exp. 2, Minor & White, *Physical Optics*, 1947.....

Each 5.50

10% discount in lots of 6

- 86220 DOUBLE AND SINGLE SLIT SOURCES, Cenco, for use in demonstrating the principle used in Michelson's measurement of stellar diameters (Exp. 8, M. & W., *Physical Optics*, 1947.)**

This consists of a pair of slits overlapping for a distance of about 1 cm near the middle of the plate, and in addition, of a single slit equal in width to the combined widths of the two slits and the opaque section between them. Two experiments may be performed with the aid of this device.

First, when a line source of light is viewed through the single and double portions of the slits, respectively, the corresponding diffraction patterns are seen. It will be noted, in viewing them simultaneously, that the fringes of the double slit lie entirely within the central maximum of the diffraction pattern of the single slit.

Second, to demonstrate the principle of Michelson's measurement of stellar diameters, No. 86210 Cenco Precision Double Slit is used with this double source. When the latter is held in the left hand against a bright background, and viewed through one of the Precision Double Slits, held close to the eye, a distance between them may be quickly found such that the maxima due to the left-hand slit of the double source fall upon the minima of the right-hand slit in the overlapping portion. The result is that the fringe system in the overlapping part becomes indistinct or disappears entirely. This happens when the angle subtended by the double source at the double viewing-slit is the wavelength of light divided by the distance between the centers of the two slits of the double viewing slits. The relation would be slightly modified if a pair of circular openings were used.

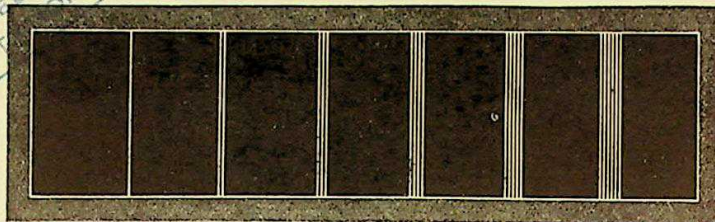
If the single slit, which is equal in width to the double slit, is used, the student will observe that the distance between the viewing slit and the source slit is just the same for disappearance of fringes as it is when the double slit is used. The experiment with the single slit is the analogy of Michelson's experiment of measuring stellar diameters, since the right and left halves of the single slit may be considered as the two sources which give the overlapping fringes.

For greatest convenience and accuracy in measuring with these slits in an undarkened room, No. 86250 Diffraction Grating is suggested. In a darkened room, two No. 86030 Object Holders on the optical bench will give good results. In cardboard case.....

Each 5.50

10% discount in lots of 6

LIGHT
Diffraction Slits



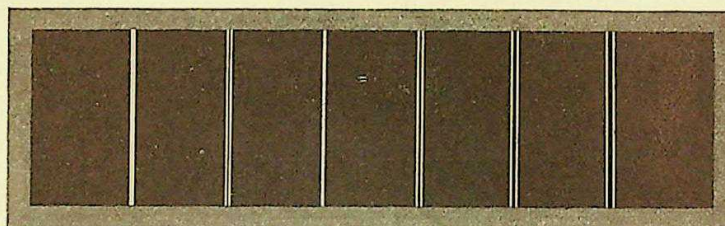
86225

86225 SINGLE AND MULTIPLE SLITS, Cenco, for an experimental study introducing the theory of the diffraction grating.

This is one of the very striking pieces in our line of specialties for diffraction and interference phenomena. There are six sets of precision slits, containing, respectively, 1, 2, 3, 4, 5, and 6 slits. The sets are so spaced that but one set at a time is seen when placed in front of a 30 mm objective of a spectrometer telescope. With the spectrometer adjusted for parallel rays, when the condensed light from an illuminator is thrown on the collimator slit, the diffraction patterns from the various sets of slits may be examined in the telescope. In addition to the principal maxima, the $n-2$ secondary maxima which lie within the principal maxima may be seen. With a suitable optical system (see No. 86200) the diffraction patterns from these sets of slits may be projected on a small translucent screen and viewed by small groups. In cardboard case.....

10% discount in lots of 6

Each \$6.60



86230

86230 DOUBLE SLITS, Cenco, six sets on a single slide, with controlled ratio of widths of spaces (a) and opaque portions or bars (b). Since the intensity distribution in the fringes for the single slit is the envelope of the interference fringes produced when a second slit is added, the ratio b/a determines the number of fringes within the central maximum of the single slit pattern. Thus the slide forms the experimental basis for such problems as this: Given, the ratio b/a ; calculate, and confirm experimentally, the number of fringes. In this series of Cenco Double Slits, the following ratios are used:

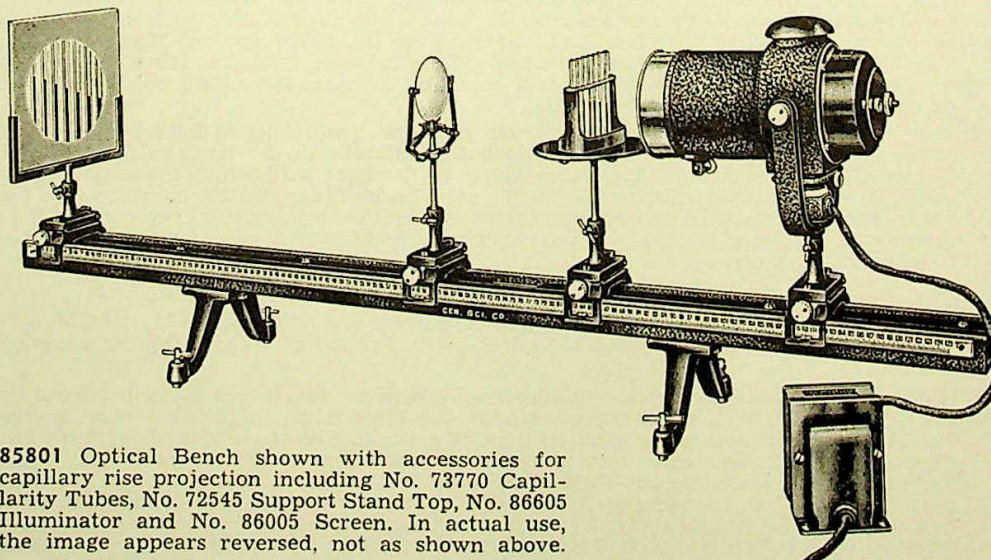
1. $a=b$; three fringes.
2. $2a=b$; five fringes.
3. $2a'=b'$; five fringes.

4. $3a=b$; seven fringes.
5. $4a=b$; nine fringes.
6. $5a=b$; eleven fringes.

See Chapter IV, Taylor's "College Manual of Optics." In cardboard case.....

Each 14.50

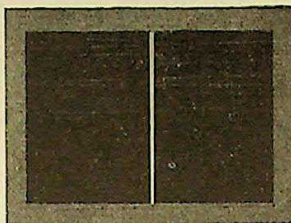
10% discount in lots of 6



85801 Optical Bench shown with accessories for capillary rise projection including No. 73770 Capillary Tubes, No. 72545 Support Stand Top, No. 86605 Illuminator and No. 86005 Screen. In actual use, the image appears reversed, not as shown above.

LIGHT

Diffraction Apparatus

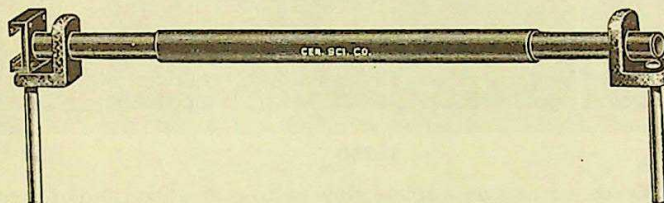


86235

- 86235 DIFFRACTION WEDGE AND DOUBLE SLIT, Cenco.** This is one of the most interesting of the Cenco Diffraction Specialties. It consists of two slits, overlapping at one end by being constructed at a very small angle with each other. At one end, where they are separated, b is slightly greater than a . Gradually b narrows down to a point, thus being like a long slender wedge, while a remains constant in width. Where b terminates in a point, a is, of course, twice the width of either slit; it narrows down to a width somewhat greater than a .

When a line source of light is viewed through this variable slit, and the latter is moved upward or downward in front of the eye, the diffraction pattern undergoes continuous change, from that corresponding to a single slit, with this slit gradually increasing in width; then the pattern produced by two slits, first with b very much smaller than a , but gradually increasing until it is somewhat greater than a . The observations and explanations of the patterns constitute an excellent qualitative experiment. In cardboard box.....Each \$4.00

10% discount in lots of 6



86240

- 86240 DIFFRACTION APPARATUS, Cenco-Minor,** for use with Nos. 86200-86242 series of Diffraction Slits in undarkened room. The apparatus is especially designed for experimental work in connection with the equations for the fringes formed by diffraction slits, and lends itself well to measurements upon the widths of fringes. (Taylor, "College Manual of Optics" Chapters 3 and 4.) It consists of two supports, one of which is designed to hold the diffraction slit or slits on which observations are to be made, the other for the eyepiece micrometer with which the readings are taken. The supports have 10 mm rods. They are so designed that the slits and focal plane of the micrometer eyepiece are on the axes of the support rods, so that the index line on the carriage correctly shows the positions of these parts relative to the millimeter scale on the bench. The support for the eyepiece also has an adapter ring so that either No. 72910 Gaertner or No. 65570 Spencer Micrometer Eyepiece may be used. Telescoping tubes, with non-reflecting inner surfaces, join the two supports, thus excluding all extraneous light, and obviating the need for a dark room. The maximum extension of the tube is about 75 cm.

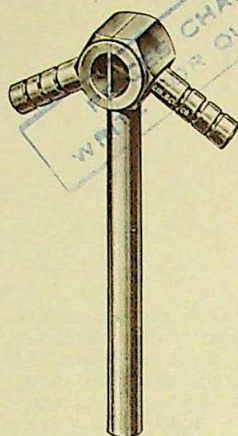
In use, No. 87271 Mercury Vapor Lamp with monochromatic filter is used as the source. One of the single slits, of desired width, is mounted adjacent to the lamp in a No. 72288 Lens Holder. This slit constitutes the direct source of the light with which the measurements are made. In some experiments the source slit may be omitted, and the mercury arc used directly. From the distance between the slit or slits and the micrometer eyepiece, and the measurement of widths of fringes, the wavelength of the light may be computed. Without slits or micrometer eyepieceEach 30.00

10% discount in lots of 6

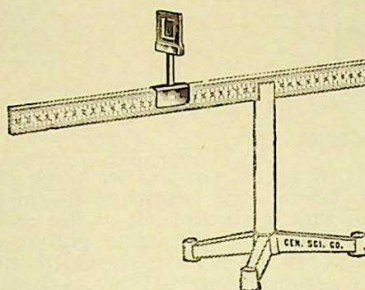
For experiments employing this or similar apparatus see White Exp. 69, p. 346; M. & W. Exp. 1, p. 1, Exp. 2, p. 6, Exp. 4, p. 13; S. E. P. L41b. See list of Manual References, page 1000.

- 86242 BIPRISM, Fresnel, Cenco,** for producing interference between two beams of light without employing diffraction. From a single source of light, the biprism produces two virtual sources; the beams from these sources overlap at a point depending on the angles of deviation produced by the biprism. In the region of overlapping, interference bands are produced. The Cenco Fresnel Biprism is designed to fit the holder of No. 86240, so that the experiment may be performed in a lighted room; or it may be used in No. 86030 Object Holder and screen for demonstration by projection. For detailed discussion of the experiment, see Minor & White, Physical Optics, Exp. 4A, p. 9; Taylor, College Optics, pp. 97 and 99.....Each 9.60

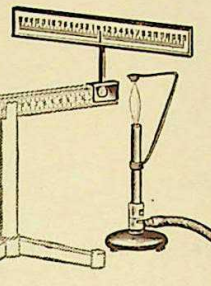
10% discount in lots of 6



86245



86250 shown in use

LIGHT
Diffraction Gratings

- 86245 INDEX OF REFRACTION OF GASES APPARATUS, Cenco-Delaup**, for use with No. 85801 Optical Bench and accessories to demonstrate the index of refraction of gases relative to air or vacuum. The device consists of a double, gas tight chamber separated by a brass wall. Each half of the chamber is provided with a hose nipple for the evacuation or introduction of gases. One end of the chamber consists of a double slit for producing diffraction fringes. One slit opens into each half of the chamber. The other end is a clear window. Thus two light paths are provided, one through each half of the chamber. A 15 cm shaft is provided for mounting in a No. 85804 Optical Bench Carriage.

In performing experiments on the index of refraction of gases, a No. 85801 Optical Bench is fitted with the following accessories: No. 86615 Straight Filament Incandescent Lamp (with No. 80305 6-volt Transformer, No. 86585 Socket and No. 85804 Carriage); No. 87117 Light Shield (with No. 85804 Carriage); No. 87308-10 Narrow Transmission Band Light Filter (with No. 72288 Filter Holder and No. 85802 Carriage); No. 85645 Focusing Lens (with No. 72288 Lens Holder and No. 85804 Carriage); No. 86245 Index of Refraction of Gases Apparatus (with No. 85804 Carriage); and No. 82370 Reading Telescope (with appropriate support).

The double slit in the interferometer produces interference fringes which are observed in the telescope. Air (or other gas) is removed from one half of the chamber (from the light path of one of the slits) and a shift of several fringes is observed. The index of refraction of the gas can be calculated from the equation:

$$\mu l - l = \lambda n$$

Where: l = length of vacuum path
 λ = wave length of light
 n = number of fringes shifted
 μ = index of refraction of air

Size of chamber, 2 cm x 2 cm, on 10 mm rod, 15 cm in length for use with optical bench. Constructed of nickel-plated brass with cemented double slit and window.....**Each \$8.00**

10% discount in lots of 6

- 86250 DIFFRACTION GRATING, Coarse, Cenco.** We have frequently had calls for a relatively coarse diffraction grating of the transmission type, with which a student would be enabled to measure wavelength of light with simple accessories, and in connection with which he could measure the grating space himself. In this manner he ascertains all the essential data by his own measurements, which has distinct pedagogical advantage over his having to accept some figure on faith. The relatively low cost of this grating makes possible the purchase of a sufficient number to supply the entire laboratory section, and puts within reach of even the small college the means for a fundamental experiment.

The ruled space has an area of approximately 16 by 10 mm. This is centrally located on the glass plate; this plate and a cover plate are bound together, to protect the ruled section against scratches or other damage. An unruled section is left unmasked, so that the student can, by shifting the eye from the ruled section to the unruled, easily judge the locations of the slit images on the scale. The grating distance is approximately 0.045 mm.

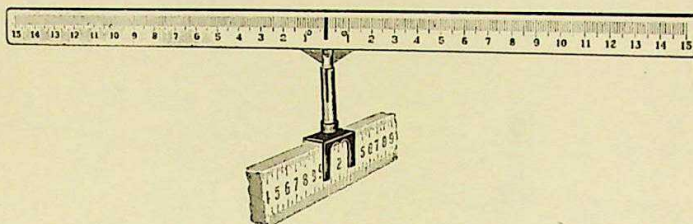
In use, in the simplest arrangement, the grating, with rulings vertical, is mounted as shown in the illustration. Upward of ten slit images (sometimes as high as the twelfth order) are observable, apparently superposed on the millimeter scale. Markers can be shifted on the latter to locate the images, and the distance of the image of each order from the slit can be found by dividing the distance between corresponding pairs of images by 2. The distance between grating and slit is then noted. The grating is next removed from the holder, and by means of a measuring microscope like No. 72931, the total width of a number of rulings is measured. From this measurement the grating distance is determined. From the data, the wavelength is computed.....**Each 2.05**

10% discount in lots of 12

For experiments employing this or similar apparatus, see I. & M. Exp. 81, p. 273; Ham. Exp. 511, p. 126; White Exp. 70, p. 351; Rich Exp. 63, p. 210; Z. & E. Exp. 14, p. 100; Min. Exp. 101, p. 148; S. E. P. L41ab.

- 86255 GRATING HOLDER, to fit No. 85905 Support.** Intended for use with our No. 86250 Grating with original ruling.....**Each 1.00**

10% discount in lots of 12

LIGHT
Diffraction Gratings


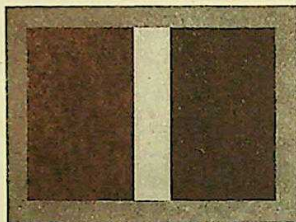
86260A

- 86260 SCALE AND SLIT**, for use with No. 86250 Diffraction Grating in wave length measurements. The apparatus consists of a metal scale 30 cm long graduated in cm and tenths on either side of zero, mounted on a metal frame with a vertical slit at the zero position. When the slit, illuminated from behind, is viewed through a diffraction grating some distance away, the various orders of spectra appear against the scale from which the location of characteristic spectral lines may be read. Two arrangements of the scale are available, one of which is mounted to slide on a meter stick turned on edge; the other is mounted on a 10 mm rod to fit a standard optical bench support clamp.

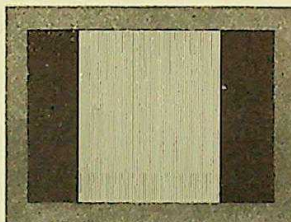
No.	A	B
Type of mounting.....	for meter stick	on 10 mm rod
Each	\$2.50	3.00

10% discount in lots of 6

For experiments employing this or similar apparatus, see S. E. P. L41ab.



86270A



86270H



87050

- 86265 DIFFRACTION GRATING, Cenco, Transmission Type, Coarse**, for measurement of resolving power. The ruled area is about 24 by 30 mm, with about 788 lines per centimeter (2000 lines per inch). The ruling is sufficiently coarse to permit measurement of the grating space with a measuring microscope, and the coarse ruling gives high intensity at the limit of resolution. In use, the grating is secured in No. 87050 Holder, and placed on a spectrometer table; a mercury lamp, like No. 87271, is used as the source. References: Minor & White, *Physical Optics*, Exp. 10, p. 37; Taylor, *College Optics*, p. 66. Each 7.25

10% discount in lots of 6

- 86270 DIFFRACTION GRATINGS, Missing Orders, Coarse Ruled.** If the equation for the intensity in the diffraction pattern from N slits (see Taylor's "College Manual of Optics" p. 55) is solved with the condition imposed that in certain selected orders the intensity shall be zero, the corresponding values of the ratio a/b may be found. Having the solution is of experimental value only if a ruling of N slits can be produced in which the required ratio of a/b is most accurately produced. The process by which these ruled gratings are produced and tested is a technical achievement of high order, and we take much pride in being the agency through which they are made available to our educational institutions.

We are presenting these rulings in two series of three each, the difference between corresponding pairs in the two series being only that of width of ruled surface. In series 1, 2, 3, the ruled area is 3 mm wide by 28 mm long; in series 8, 11, 12, the width is 25 mm. Since the greater ruled width results in much greater intensity, the second group is suited for projection of the fringes as well as visual observation either directly or with a measuring eyepiece, whereas the first group is intended only for laboratory purposes.

Numbers 1 and 8 are so ruled that $2N$ orders are missing, i.e., 2, 4, 6, 8, etc.

Numbers 2 and 11 show absence of the $3N$ order, i.e., 3, 6, 9, 12, etc.

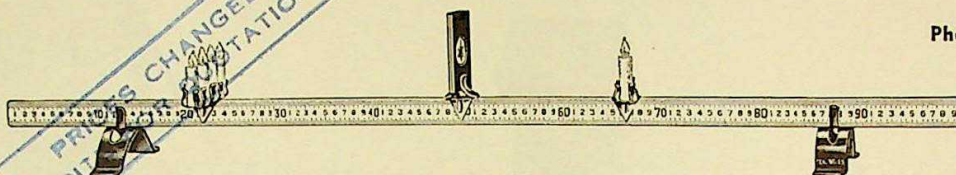
Numbers 3 and 12 produce extinction in the $4N$ orders, i.e., 4, 8, 12, etc.

With the 8, 11, 12 series, projection of 7 orders can readily be accomplished on No. 86005 Screen with No. 86605 Illuminator and a red filter.

No.	1	2	3	8	11	12
Width of ruled space, mm.....	3	3	3	25	25	25
Missing orders	2N	3N	4N	2N	3N	4N
Each	6.00	6.00	6.00	16.00	16.00	16.00

10% discount in lots of 6

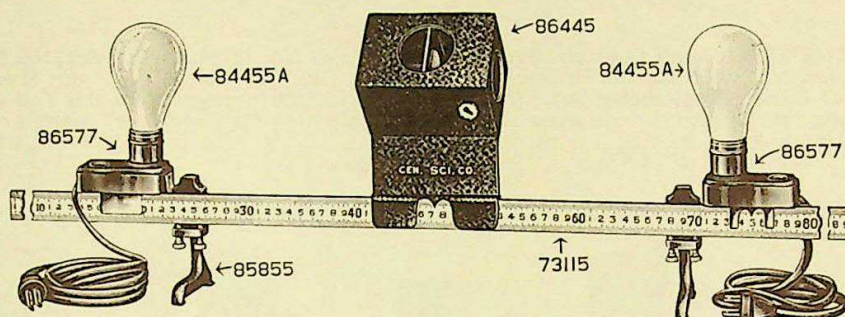
- 87050 HOLDER, Mirror and Grating**, for supporting mirrors or gratings either on a spectrometer table or in an optical bench. Consists of a cast mounting with two faces at right angles machined smooth. One of them has a square aperture about 30x35 mm and is provided with spring clips to support objects up to 50x50 mm. The other surface is used as the base. It has a threaded hole for a standard 10 mm rod. Each 4.60

LIGHT
Photometers

86310

- 86310 PHOTOMETER, Elementary,** includes No. 73115 Meter Stick, No. 85850 Metal Supports, No. 86520 Candle Holder, No. 86522 Candle Holder, No. 85960 Screen and No. 85970 Screen Support. **Each \$2.15**

10% discount in lots of 6



86322 shown with No. 84455A Lamps

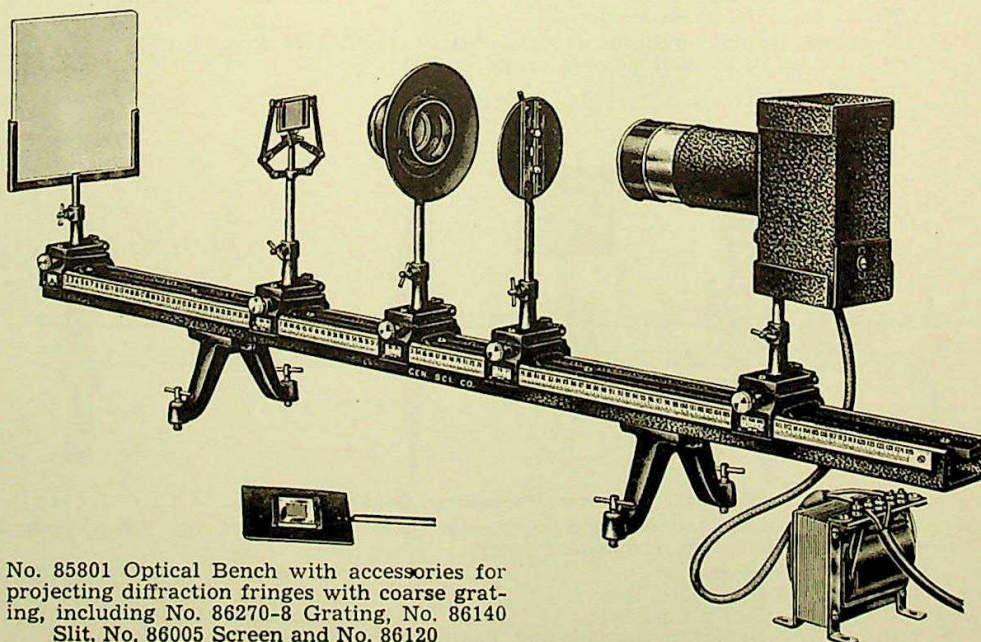
- 86315 PHOTOMETER, Student's, Bunsen Form.** Includes No. 73115 Meter Stick, No. 86530 Candle Holder, No. 86555 Gas Burner and No. 86445 Bunsen Photometer Box. **Each 8.60**

10% discount in lots of 6

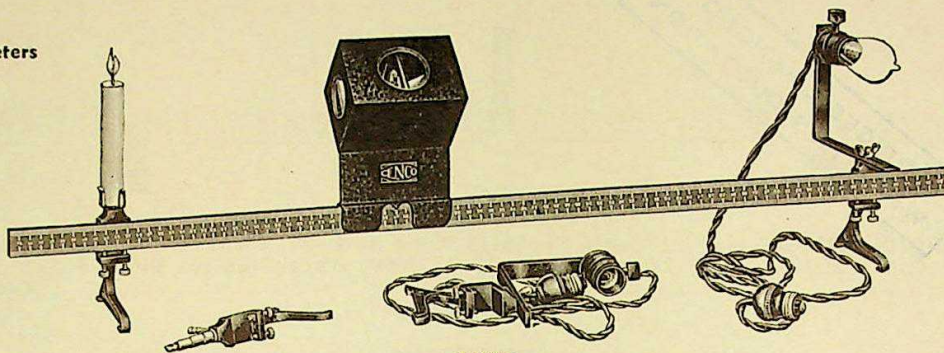
- 86322 PHOTOMETER, Student's Bunsen Form, Incandescent Lamp,** for student use in secondary physics experiments in photometry. May also be used for experiments in optics by replacing the photometer box with lens and screen holders, as the optical light sources are excellently adapted to these experiments.

Consists of a No. 73115 Meter Stick; a pair of No. 85855 Meter Stick Supports; 2 No. 86577 Optical Light Sources with 15-watt, 115-volt incandescent lamps, connecting cords and attachment plugs; and a No. 86445 Bunsen Photometer Box. For photometric comparisons of the intensity of illumination from incandescent electric lamps, it is recommended that lamps of wattages usually used for illumination, such as Nos. 84445 and 84455 Lamps, be substituted for the 15-watt lamps supplied with the optical light sources. **Each 10.75**

10% discount in lots of 6



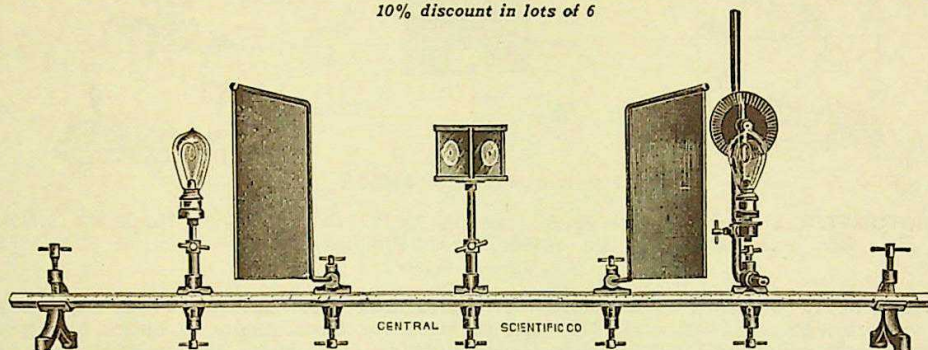
No. 85801 Optical Bench with accessories for projecting diffraction fringes with coarse grating, including No. 86270-8 Grating, No. 86140 Slit, No. 86005 Screen and No. 86120 Projection Objective

**LIGHT
Photometers**


86325

86325 PHOTOMETER, Student's Complete, Bunsen Form. Includes No. 73115 Meter Stick, No. 86530 Candle Holder, No. 86532 Candle Holder, No. 86555 Gas Burner, No. 86580 Lamp Socket and No. 86445 Bunsen Photometer Box. In connection with the necessary candles and incandescent lamps, this outfit makes a most satisfactory equipment for elementary work in photometric measurements Each \$14.75

10% discount in lots of 6

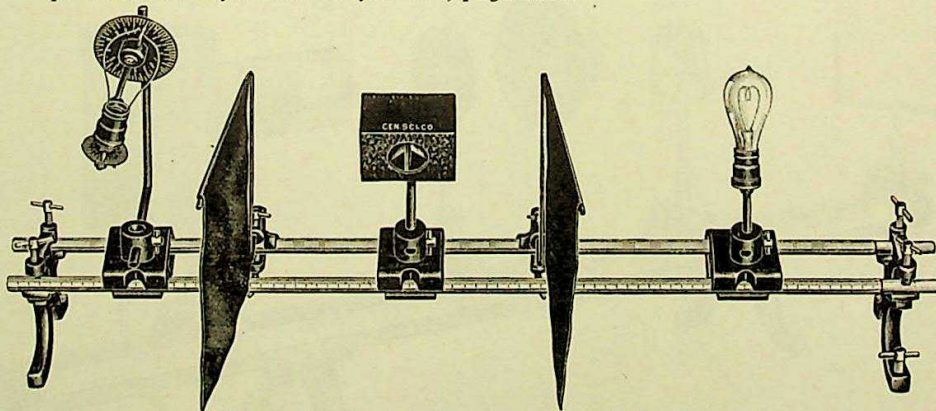


Advanced Laboratory Photometer, Single Rod Type

The advanced laboratory, single rod photometer, used for standardizing incandescent lamps, consists of the following component parts:

1 No. 72216B Graduated Rod	1 No. 72310B Clamp
2 No. 72220 End Supports	1 No. 86455 Bunsen Photometer Box
1 No. 84475 Standard Incandescent Lamp	1 No. 72322 Clamp
2 No. 86585 Lamp Socket	Pr. No. 86665 Eye Shades
1 No. 72322 Clamp	2 No. 72322 Clamps
1 No. 86595 Universal Holder	

For experiments employing this or similar apparatus see I. & M. Exp. 71, p. 241; Z. & E. Exp. 1, p. 81. See list of Manual References, page 1000.



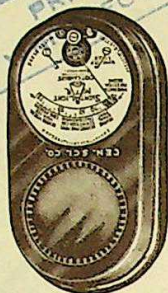
Advanced Laboratory Photometer, Double Rod Type

The advanced laboratory, double rod photometer, used for standardizing incandescent lamps, consists of the following component parts:

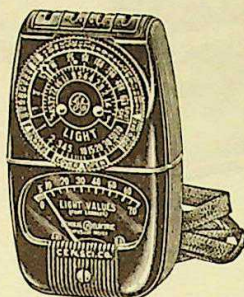
1 No. 72210B Plain Rod	1 No. 86595 Universal Holder
1 No. 72216B Graduated Rod	1 No. 86455 Bunsen Photometer Box
Pr. No. 72222 End Supports	3 No. 72230 Clamps
1 No. 84475 Standard Incandescent Lamp	Pr. No. 86665 Eye Shades
1 No. 86585 Lamp Socket	2 No. 72322 Clamps

LIGHT
Photometers
Photometer Boxes

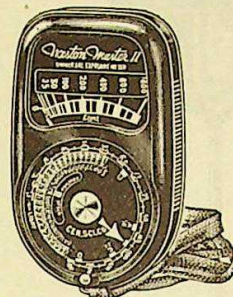
PRICES CHANGED
 FOR QUOTATION



86405



86415



86420

- 86405 PHOTOMETER, Weston Photronic, (Foot Candle Meter),** for measuring intensity of illumination. This compact instrument is a combination of two well-known Weston items—the Photronic Cell and a Weston Milliammeter. The latter is calibrated to read foot-candles directly within the range 0 to 75. The Photronic Cell produces a current proportional to the intensity of illumination falling upon it, so that the deflections of the meter are likewise proportional to illumination. The instrument may be used for checking either daylight or artificial illumination. As a laboratory device, it may be used as a photometer, for measuring the intensity of illumination produced by a given source at different distances, and experimental evidence of the inverse square law obtained. The Photronic Cell and meter are both mounted in a housing of molded Bakelite, with over-all dimensions of 2½ by 4½ by 1½ inches.....Each \$21.06

- 86415 PHOTOMETER, G-E EXPOSURE METER, Photoelectric,** for use same as No. 86405, and may be used as a photographic exposure meter in addition. By removing the hood, it becomes a light meter calibrated directly to read from 0 to 70 footcandles. The brightness range is from 0.05 to 1700 candles per square foot. As a photographic exposure meter, it lists A.S.A. film speeds up to 800, diaphragm values from F:1 to F:45 and shutter speeds from 120 seconds to 1/800 second. Complete with neck cord, photo data book and instructions for use.....Each 17.37*

- 86420 PHOTOMETER, Weston Model 735 Exposure Meter, Photoelectric,** for use same as No. 86405, and for still or movie cameras in daylight or artificial light. Calibrated from 0 to 1600 Weston. Has extreme high and low brightness range with readable high sensitivity for indoor work. The 30° viewing angle is especially suited for color and cine work. A wider range of f:stop-shutter combinations is possible than with former types of meters. Provision is made for filter factor compensations, as well as maximum allowances for over or under-exposure. With neck cord, data book and instructions, but without case.....Each 25.71*

*Federal excise tax extra, if applicable.

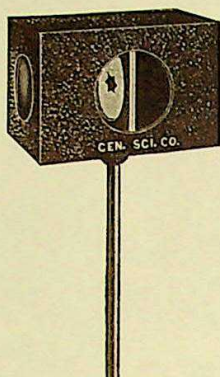


86445

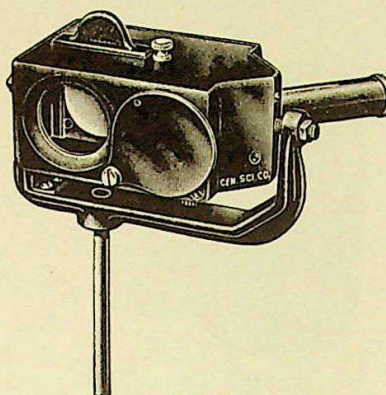
- 86445 PHOTOMETER BOX, Bunsen-Dibdin, Meter Stick Type,** fitted with slot for sliding on an ordinary meter stick and containing a Bunsen-Dibdin photometer screen with two mirrors at an angle so that both sides of the screen may be viewed at the same time. It is important to keep in mind that this is not an equality-of-brightness screen but an equality-of-contrast screen. Settings which are sufficiently close for laboratory work with the simple optical bench can be obtained either by shifting the photometer box until apparently equal contrast between the pattern and the surrounding region is obtained on both sides, or the photometer box may be shifted to each of the two positions at which most nearly equal brightness is obtained in the pattern and the surrounding area on the two respective sides. The mean of these two positions would correspond to the point at which an equality of contrast is obtained. Complete with indicator, but without meter stick.....Each 4.15

10% discount in lots of 6

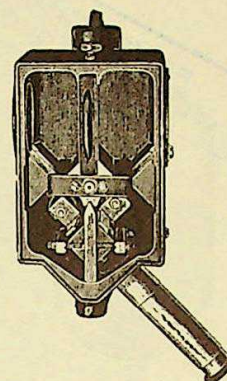
LIGHT Photometer Boxes



86455



86460



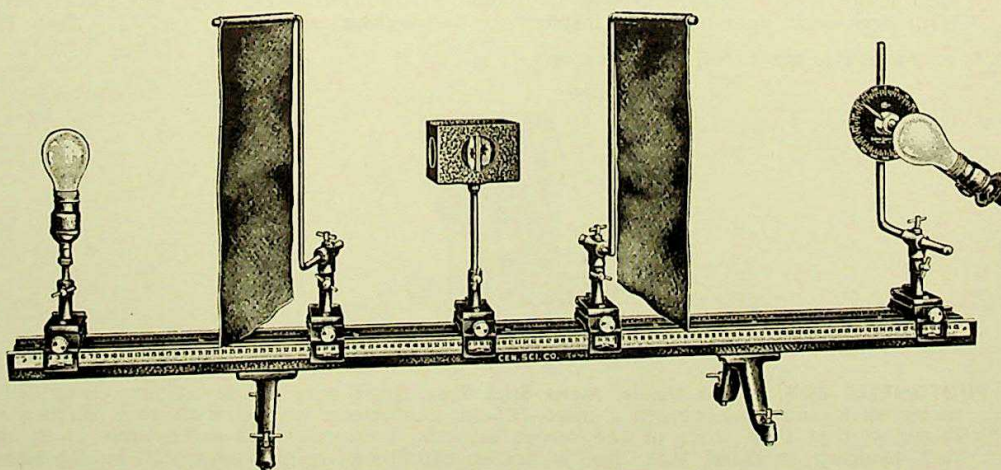
Top view of No. 86460
showing internal arrangement

- 86455 PHOTOMETER BOX, Bunsen-Dibdin, Optical Bench Type**, for use on optical benches using rod-mounted accessories. A Bunsen-Dibdin screen similar to that described under No. 86445 Box is used within the housing. Finished in black wrinkle enamel and fitted with a nickel-plated rod 15 cm long by $\frac{3}{8}$ inch (10 mm) in diameter.....**Each \$6.75**

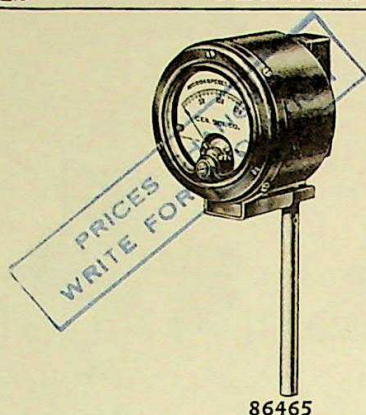
10% discount in lots of 6

- 86460 PHOTOMETER BOX, Lummer-Brodhun, Optical Bench Type, L. & N.**, for either contrast or equality of brightness method. The sight box with its photometric cube and magnesium carbonate comparison surfaces and with observing eyepiece consists of the several parts assembled in a molded bakelite housing. This is swiveled on a horizontal axis so that measurements may be repeated with the comparison surfaces reversed. The casting in which the sight box rotates is mounted on a $\frac{3}{8}$ inch rod for use in standard optical bench carriages. An adapter is provided to permit the use of Nos. 72160-72166 Rods with $\frac{1}{4}$ "-20 threads for supporting the photometer box on our optical bench carriages. Complete with book of directions..**Each 275.00**

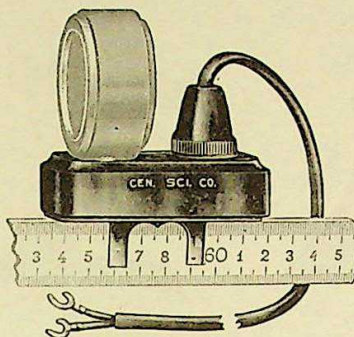
For experiments employing this or similar apparatus see White Exp. 63, p. 321; T. W. & H. Exp. 43, p. 119; D. C. M. Exp. 101, p. 210; M. G. & E. Exp. 48, p. 185; Terry, Exp. 35, p. 225. See list of Manual References, page 1000.



No. 85801 Optical Bench with accessories for photometric experiments, including No. 86455 Photometer Box, No. 86595 Universal Holder, No. 86585 Lamp Socket, No. 84480 Lamps, No. 86665 Eye Shades, No. 85805 Clamps and No. 85804 Carriages



86465



86475

LIGHT
Photometer Head
Candle Holders

- 86465 PHOTOMETER HEAD, Photoelectric**, for use on an optical bench for demonstrating the inverse-square law and for measuring and comparing light intensities. Consists of a Weston Microammeter on the back of which a sensitive barrier-layer photoelectric cell is mounted in such a position that the plane of the sensitive layer of the cell contains the axis of the support rod so that the index mark on the supporting optical bench carriage correctly shows the location of the sensitive layer of the cell.

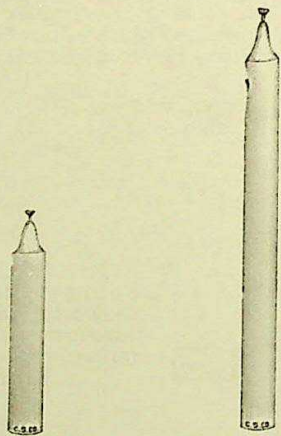
The microammeter has a scale 50 mm long for a range of 200 microamperes which is divided into 40 scale divisions of 5 microamperes each. The meter resistance is approximately 55 ohms. A 10 mm support rod permits its mounting in a No. 85802 Optical Bench Carriage or other suitable optical bench support. **Each \$51.00**

5% discount in lots of 3

For experiments employing this or similar apparatus, see S.E.P. L12b. See list of Manual References, page 1000.

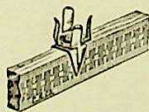
- 86475 PHOTRONIC CELL HOLDER**, for holding a No. 80915 Photronic Cell on a meter stick to make the same measurements of light intensities as described under No. 86465 Photometer Head, when it is desired to use a galvanometer or microammeter already in the laboratory as the current meter. No. 82115 Galvanometer, used as a microammeter, will give very satisfactory performance. Consists of a bakelite molding with meter stick rider, socket for Photronic cell, and a pair of connecting leads for the current meter. The index line of the mounting is placed directly beneath the sensitive film of the Photronic cell for correct indication of meter stick distances. **Without current meter or Photronic Cell. Each 2.50**

10% discount in lots of 6

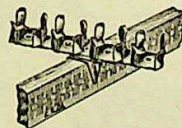


86505

86515



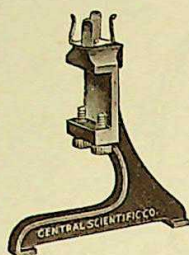
86520



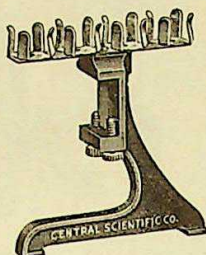
86522

- 86500 CANDLES, Christmas**. Size, $\frac{3}{8} \times 3\frac{1}{4}$ inches. In boxes of 24. **Per box .22**
10% discount in lots of 50 packages
- 86505 CANDLES, Paraffin**. Size, $\frac{7}{8} \times 4\frac{3}{4}$ inches; twelve weigh one pound. Sold in dozens only. **Per dozen .34**
10% discount for Cenco Package of 36 dozens
- 86510 CANDLES, Paraffin**, same as No. 86505 but twice as long, weighing six to the pound. In packages of 12. **Each .65**
10% discount for Cenco Package of 20 dozens
- 86515 CANDLES, Standard, Sperm**, six to the pound, will burn 120 grains (7.776 grams) of wax per hour. Size, $\frac{7}{8}$ by $9\frac{1}{2}$ inches. **Each .55**
10% discount for Cenco Package of 24
- 86520 CANDLE HOLDER**, for one candle, of metal, to slide on meter stick. **Each .15**
10% discount for Cenco Package of 50
- 86522 CANDLE HOLDER**, for four candles, of metal, to slide on meter stick. **Each .50**
10% discount in lots of 12

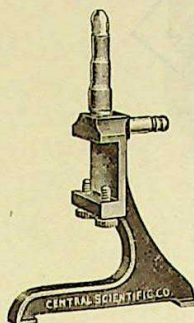
LIGHT Lamp Supports



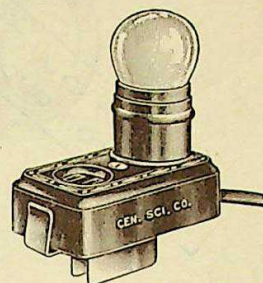
86530



86532



86555



86577

86530 CANDLE HOLDER, Mounted. Consists of a candle holder for one candle, mounted on a No. 85855 Support Each \$1.30

10% discount in lots of 12

86532 CANDLE HOLDER, Mounted. Consists of a candle holder for four candles, mounted on a No. 85855 Support Each 1.80

10% discount in lots of 6

86555 GAS BURNER, Mounted. Consists of a standard gas pillar with aluminum gas tip, mounted on a No. 85855 Support..... Each 2.65

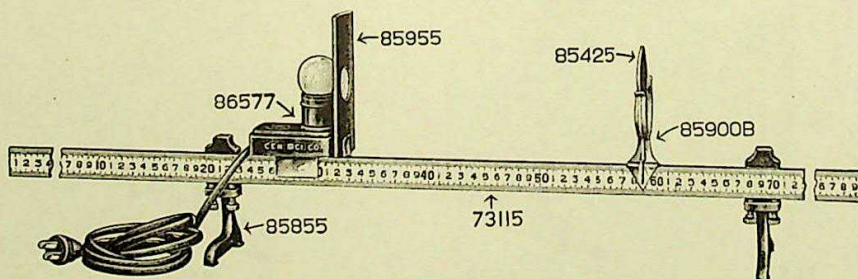
10% discount in lots of 6

86577 LAMP SUPPORT AND LIGHT SOURCE, Meter Stick Type, for use with meter stick optical benches for laboratory experiments in light, such as finding the focal length of a convex lens; focal length of concave mirror; projecting a real image with concave mirror, and intensity of light with bench and photometer box.

Consists of a molded receptacle with two outlets connected in parallel. With clip for holding an object screen and a metal support to permit sliding on a meter stick. A standard keyless socket with 7.5-watt, 115-volt lamp is provided for plugging into one of the outlets. The second outlet permits a voltmeter to be shunted across the lamp. With two of these pieces and a voltmeter, an ammeter, a rheostat, a standard carbon lamp and a photometer box, the candle power of an ordinary incandescent lamp may be determined quite accurately. If desired, the standard carbon lamp may be omitted and comparison made of the candle power of two incandescent lamps of different wattage.

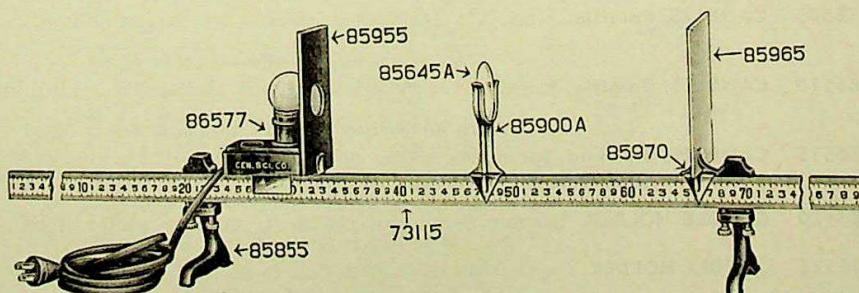
Complete with lamp, lamp socket, clip for supporting object screen, and a six-foot connecting cord with plug..... Each 2.40

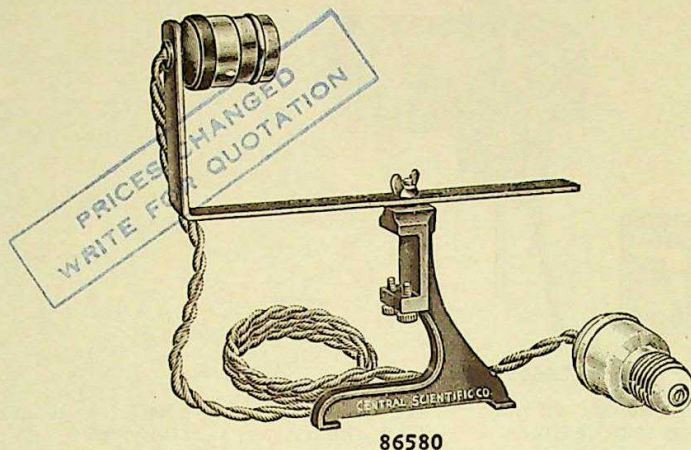
10% discount for Cenco Package of 6



At left: No. 86577 Lamp Support and Light Source shown in optical bench assembly for image formation by concave mirror

At right: Same as above but for image formation by convex lens



LIGHT
Lamp Sockets

86580



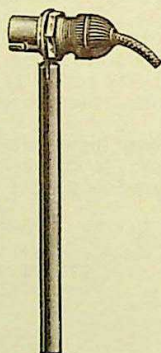
86585

- 86580 LAMP SOCKET, Mounted.** Consists of a standard, medium screw base lamp socket adjustably mounted on a No. 85855 Support so that either the horizontal or tip candle power of any ordinary incandescent lamp may be measured when the device is used with a photometer box. **Each \$4.25**

10% discount in lots of 6

- 86585 LAMP SOCKET, Optical Bench Type, Medium Screw Base,** for holding an incandescent lamp. Mounted on a rod to fit No. 72322 Clamp. **Each 1.90**

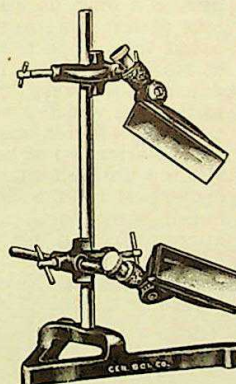
10% discount in lots of 12



86590



86595



86600

- 86590 LAMP SOCKET, Optical Bench Type, Bayonet Base,** for single contact bulbs. The detachable rod is 15 cm long by $\frac{3}{8}$ inch in diameter, with the socket mounted at right angles to the rod. This mounted socket can be used to provide a source of light on an optical bench, since the rod fits all standard carriages. It will accommodate any single contact, automobile type, bayonet base incandescent bulb. Used with No. 95120 Bulb, the assembly provides a convenient and adequate source of illumination for the oil droplets in No. 71260 Millikan-Palmer apparatus. With 3 ft. connecting cord with spade terminal connectors. **Each 6.50**

10% discount in lots of 6

- 86595 UNIVERSAL HOLDER,** for holding the unknown incandescent lamp at different angles, with graduated disk, adjustable arm and lamp socket, to fit Nos. 72310B and 85805 Clamps. **Each 14.50**

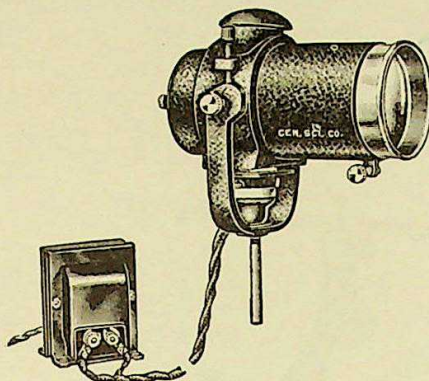
10% discount in lots of 6

- 86600 HELIOSTAT, Manually-Operated, Cenco,** for directing a beam of sunlight in any desired direction, and, by simple manual adjustment at intervals, keeping the beam directed as desired. It is intended especially for use in the demonstration lecture where illumination of the slit of a spectroscope with sunlight is desired, and where the beam needs to be kept on the slit for a few minutes at a time. The instrument consists of two mirrors with silver-coated backs, mounted with double friction-joints on $\frac{3}{8}$ inch support rods, and held with suitable right-angle clamps on a Cenco-Harrington physical support.

In use, the longitudinal axis of the lower mirror is adjusted to be approximately in "equatorial" mounting, i. e., parallel to the earth's axis. The mirror is then inclined on its transverse axis so that the beam is reflected upward to the second mirror, which in turn is adjusted so that the beam is directed as needed. The beam is then kept approximately constant in direction with a single manual adjustment, namely, an occasional slight rotation of the lower mirror about its equatorial axis. With clamps and support stand. **Each 18.00**

10% discount in lots of 6

LIGHT
Illuminator



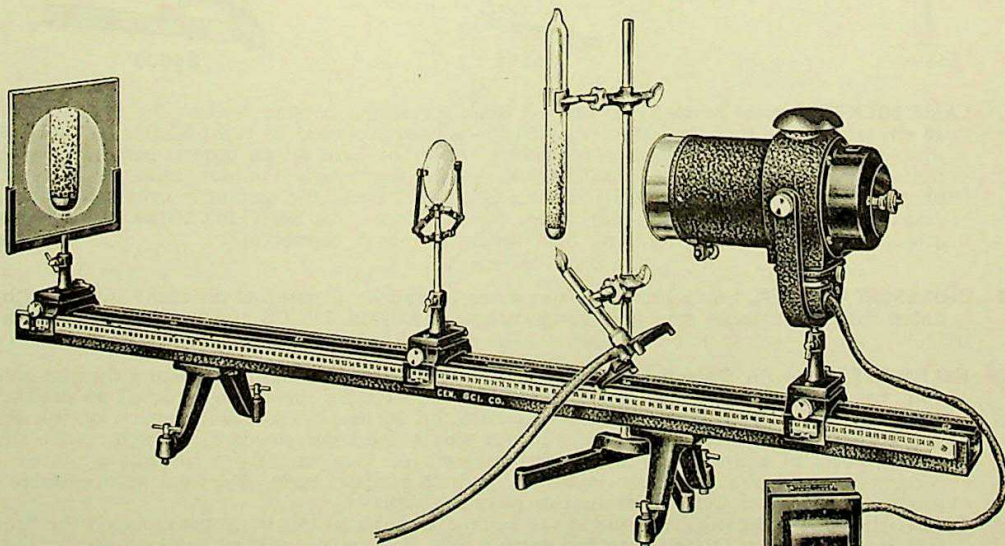
86605

86605 ILLUMINATOR, Optical Bench, Cenco, for all purposes requiring a beam of light of high intensity. For operation on alternating current only. This illuminator will be found one of the most generally useful units of the demonstration equipment. The light source is a 6-volt, 18-ampere projection bulb with concentrated filament, supplied with current from a special transformer which is part of the outfit. The bulb is adjustably mounted in a substantial, well-ventilated housing, fitted at the rear with an adjustable concave mirror and at the forward end with a pair of $4\frac{1}{2}$ inch condensing lenses in a telescoping mount, and a clamp for holding the condenser in fixed position. The mirror and bulb are relatively so adjustable that the filament is at the center of the curvature of the mirror, thereby bringing about coincidence between the filament and its real image, and materially increasing the brightness of the source. The condenser mount can be adjusted for focus of the filament at any distance, or for parallel rays, and a clamp fixes it in its adjusted position. The housing is held in a fork, on a horizontal axis, with a tangent screw stop by means of which the optical axis of the system may be adjusted to any desired working angle. The fork support is secured to a $\frac{3}{8}$ inch rod about 10 cm long. This permits supporting the unit in the carriage of No. 85801 Optical Bench, or by means of standard physical supports on a tripod base. Because of the very small area of the concentrated filament, this unit is suitable for all projections in which a very small, exceedingly bright source is required. Its intensity is sufficient for all demonstration projections, including experiments in diffraction, interference, and polarization of light.

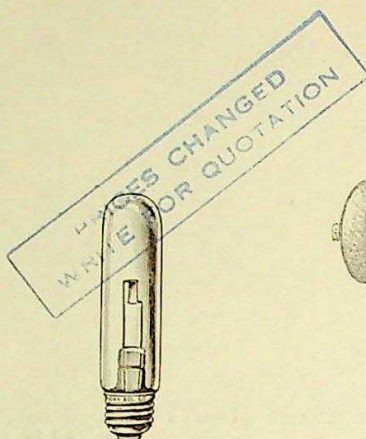
The lamp without the condensers is an excellent light source for shadow projection, or for projection by the Schlieren method. It makes an excellent "spotlight" for intensely illuminating some particular part of a demonstration setup. It can also be used as a light source in microprojection, photomicrography, and in vertical projection.

No.	A	E
For cycles at 115 volts A.C.	60	25
Each	\$77.50	81.50

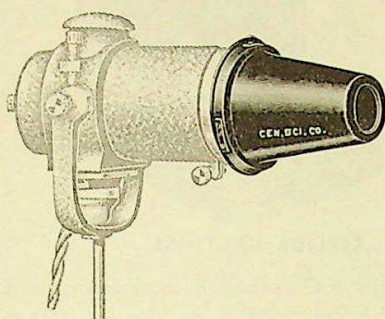
5% discount in lots of 3



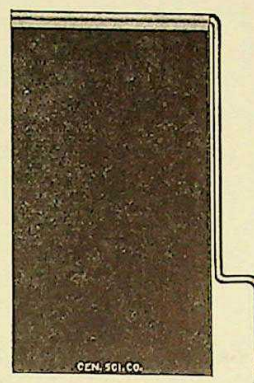
No. 85801 Optical Bench with accessories for molecular motion demonstration, including No. 77725 Stoekle Tube, No. 86605 Illuminator, No. 11002A H-Base Burner, and No. 72003 Harrington Base with rod. In actual use, the image is inverted, not erect as shown.

LIGHT
Replica Gratings

86606



86607 shown in use



86665

- 86606 LAMP, Incandescent**, with tungsten strip filament, for use in Nos. 86605 and 29540 Illuminators. In experiments requiring a small light source of uniform brightness, this bulb serves the purpose very well. Its strip filament, except at the ends, gives an image of uniform intensity on a slit, so that for interference and diffraction experiments it gives somewhat better results than No. 66162, which has a six-turn coiled wire filament. For 6 volts, 18 amperes. **Each \$6.00***
- 66162 Bulb**, only, for replacement in No. 86605 Illuminator. For 6 volts, 18 amperes. **Each 1.80***
- 86607 LIGHT SHIELD** for No. 86605 Illuminator. Consists of a cone-shaped hood which fastens with knurled-head screws to the front end of the condenser mount. Its purpose is to confine all stray light, thereby improving the visibility of demonstrations. The hood is of black-finished spun metal. Its forward end has a two-inch diaphragm through which the light beam passes. **Each 4.85**
- 10% discount in lots of 6*
- 86615 LAMP, INCANDESCENT, Straight Filament**, for 6 volts, 3.5 amperes, with standard medium screw base. This lamp is a suitable line source of light for use with Nos. 86200 to 86235 Slits. In a demonstration to a large group, in which individual students look at the source through the ruled slits, it is especially suitable because it can be seen from all parts of the room simultaneously. When the lamp is to be used for optical bench work, it can be mounted in No. 86585 Lamp Socket to fit No. 85802 Carriage. May be operated from a 115-volt A.C. source through No. 80305 Transformer. **Each 1.60***
- 86665 EYE SHADES**, for shading the eyes of the observer from the lights being compared in photometric measurements. Made of black cloth, about 25x38 cm, mounted on $\frac{3}{8}$ inch rod, having an offset bend to aid in removing the shade from the light path, and another bend near its extremity to permit insertion in the vertical hole of the usual optical bench clamps, such as Nos. 85802 and 85804 Carriages and No. 72322 Clamp. **Per pair 4.15**
- 10% discount in lots of 6 pairs*

*Federal excise tax extra, if applicable.

REPLICA GRATINGS

For more than thirty years replica gratings made by Dr. R. James Wallace were sold by The Central Scientific Company. Dr. Wallace was highly skilled in producing replicas of original diffraction gratings. He perfected the art while a member of the staff at Yerkes Observatory. For more than forty years he made replica gratings.

Prior to his death, Dr. Wallace trained certain personnel of Central Scientific Company in the techniques required to make these replica gratings. Since then, replica gratings have been made in our laboratories. The replicas are taken from the same originals used by Dr. Wallace. These are originals ruled either by Rowland, Michelson, or Carnegie Institute.

Slight unavoidable variations in the mounting process result in a difference in definition which necessitates classification of the gratings into three grades of quality, A, B and C. The less perfect grade is listed at a lower price. Also during the stripping and drying process the casts contract measurably, increasing slightly the number of lines to the inch, thus altering the "grating constant." The number of lines per inch as given in the description is that of the original from which the replica is taken. Grades A and B are mounted on

the best grade of optical glass with ground edges, 4.5 x 5 cm in size.

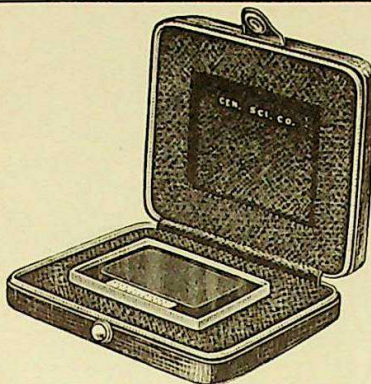
Grade A gratings are carefully selected for appearance and tested on a precision spectrometer for definition and sharpness of the spectral lines in the first order spectrum.

Grade B gratings may have slight imperfections in appearance and while not giving quite a perfect definition and as sharp spectral lines, are satisfactory for many purposes. All Grade A and Grade B gratings are enclosed in fabricoid covered lined cases, to protect them against damage.

Grade C gratings are bound between thin plates of lantern slide glass. A black mask between the plates exposes only the ruled area of the grating. These gratings are examined in a No. 86950 Spectroscope and each grating will produce a spectrum of well defined lines of an arc or spark source. They are satisfactory for most laboratory, chemical laboratory and projection purposes.

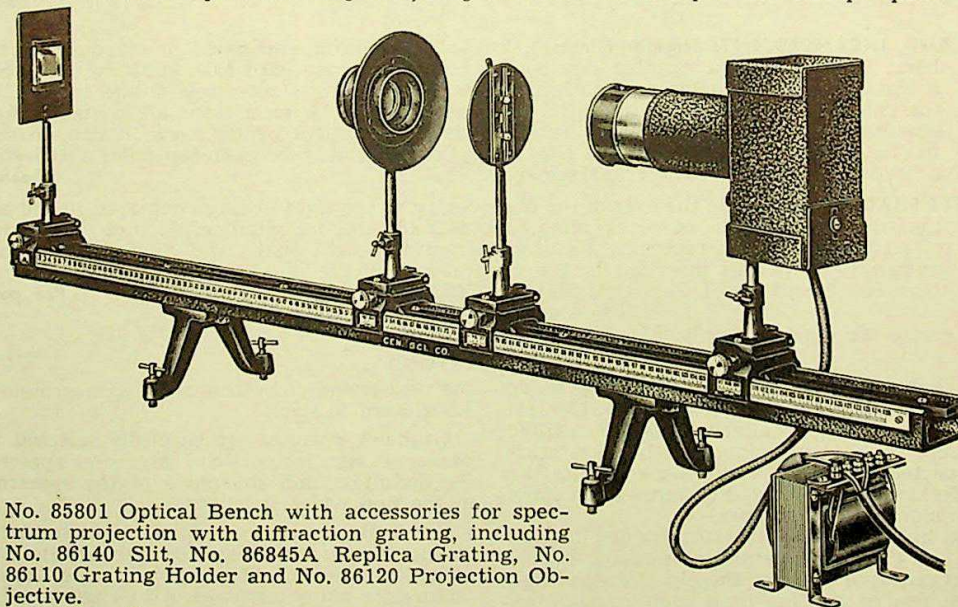
All gratings are labeled to show the approximate number of lines per inch.

For complete specifications on Replica Gratings, consult the listing on the following pages.

**LIGHT
Replica Gratings**

REPLICA GRATINGS

- 86700 **GRATING, Elementary, Replica**, 7500 lines per inch, mounted upon a single glass plate, 5 by 5 cm in size. Ruled surface 20 x 25 mm.....**Each \$3.50**
10% discount in lots of 6
- 86705 **GRATING, Elementary, Replica**, 15000 lines per inch, mounted upon a single glass plate, 5 by 5 cm. Ruled surface 20 x 22 mm.....**Each 2.75**
10% discount in lots of 6
- 86706 **GRATING, Elementary, Replica**, 15000 lines per inch, mounted upon a single glass plate 82 x 100 mm in size. Ruled surface 60 x 70 mm.....**Each 10.00***
- 86707 **GRATING, Elementary, Replica**, 25000 lines per inch, mounted upon a single glass plate 5 x 5 cm. Ruled surface 20 x 25 mm.....**Each 3.50**
10% discount in lots of 6
- 86708 **GRATING, Elementary, Replica**, 25000 lines per inch, mounted upon a single glass plate 82 x 100 mm in size. Ruled surface 27 x 45 mm.....**Each 10.00***

*Note: Price applies to single grating replica, bought separately. If Nos. 86706 and 86708 Replicas are to be purchased together, they are available as a pair at 16.00 per pair.

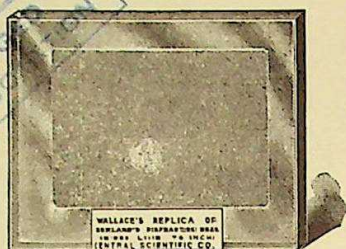


No. 85801 Optical Bench with accessories for spectrum projection with diffraction grating, including No. 86140 Slit, No. 86845A Replica Grating, No. 86110 Grating Holder and No. 86120 Projection Objective.

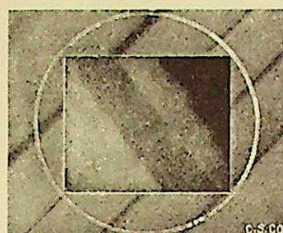


PRINCIPAL SERIES									
SHARP									
DIFFUSE									
MERCURY LINES									

Spectrogram made with a No. 86896 Concave Replica in No. 87102 Cenco Grating Spectrograph by Professor D. A. Wells, University of Cincinnati. The spectrum is that of potassium, using as the source of light a vapor lamp similar to No. 87286 Cenco B-W Vapor Lamp.



86745



86810-86845

LIGHT
Replica Gratings

GRATINGS, Transmission Replica

Catalog Number	Size of Ruled Surface, mm	Lines per inch in original	Grade A Each	Grade B Each	Grade C Each
86710	20 x 25	7500	\$7.00	5.50	4.25
86720	20 x 25	10000	7.00	5.50	4.25
86735	20 x 25	15000	7.00	5.50	4.25
86745	20 x 25	25000	7.00	5.50	4.25
86771	13 x 13	7500		5.00	
86772	13 x 13	10000		5.00	
86773	13 x 13	15000		4.00	
86774	13 x 13	25000		5.00	

10% discount in lots of 6 of one type

Nos. 86771 to 86774 gratings are mounted upon optical glass 25 x 25 cm with ground edges. The ruled surface is 13 x 13 mm, and the gratings are of grade B quality.

Note: The number of lines per inch on a replica is slightly higher than the number on the original grating as slight dimensional changes occur in the collodion film during manufacture. Under no condition should gratings be washed with alcohol or other solvents. To remove dust or lint from the grating, brush the surface carefully with a soft camel's hair brush.

For experiments employing the above or similar apparatus, see I. & M. Exp. 81, p. 273; Ham. Exp. 511, p. 126; White Exp. 70, p. 351; Rich Exp. 63, p. 210; Z. & E. Exp. 137, p. 250, Exp. 138, p. 252; T. W. & H. Exp. 51, p. 143; Min. Exp. 101, p. 148, Exp. 103, p. 155, Exp. 104, p. 160; Tay. Exp. 5, p. 62; D.C.M. Exp. 113, p. 249; M. G. & E. Exp. 54, p. 208. See list of Manual References, page 1000.

Plane Reflection Replica Gratings

These are grating replicas mounted upon heavily aluminized plane glass surfaces 4.5 x 5 cm. These gratings may be used in the same manner as the original gratings.

Note: In ordering, be sure to specify catalog number and grade.

Catalog Number	Size of Ruled Surface, mm	Lines per inch in original	Grade A Each	Grade B Each
86810	20 x 25	7500	9.50	7.60
86818	20 x 25	10000	8.25	6.60
86835	20 x 25	15000	7.00	5.50
86845	20 x 25	25000	9.40	6.60

10% discount in lots of 6 of one type

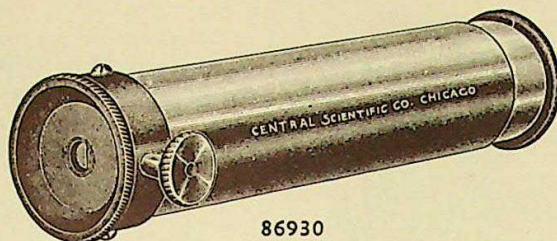
Concave Reflection Replica Gratings

These replica gratings are mounted on heavily aluminized concave glass surfaces which are held in a suitable molded black bakelite housing. A black paper mask exposes only the ruled portion of the grating surface.

Catalog Number	Size of Ruled Surface, mm	Lines per inch in original	Focal Length, cm	Grade A Each	Grade B Each
86886	20 x 25	15000	42.5	17.00	13.60
86887	20 x 25	15000	108.0	17.00	13.60
86896	20 x 25	25000	42.5	20.00	16.00
86897	20 x 25	25000	108.0	20.00	16.00

10% discount in lots of 6 of one type

LIGHT
Spectroscopes

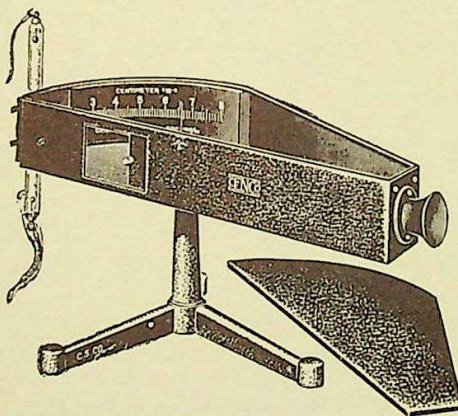


86930

86930 SPECTROSCOPE, Wallace's Direct Vision Diffraction, Pocket Form. This instrument is modeled somewhat on the lines of that of Thorp of England, but has been much improved and rendered more adaptable for general use. The dispersion piece consists of a 15,000 line replica which is mounted upon a 30° prism of light crown glass. The only object served by the prism is to deviate the direct image of the slit, which is thus thrown to one side out of the field of view, while the brilliant spectrum of the first order is seen in direct line of sight. By directing the vision at a small angle and using a sufficiently bright light, the spectrum of the second order is readily available, which, with its greatly increased dispersion, is more suited for some observations. The collimating lens is of high quality and strictly achromatic, thus enabling the Fraunhofer lines to be defined sharply throughout a greater area in the spectrum than would be possible with a simple uncorrected lens, which would bring the lines in each color to a focus at a different plane.

The slit mechanism is of the form usually supplied on a much higher grade of European instrument and is exceedingly ingenious in pattern. It is adjustable by means of a screw with milled head, which gives a smooth and even motion to the movable jaw. With direct sunlight (or electric arc) the D lines are shown well and clearly resolved in the spectrum of the second order and with critical focusing, even in the first order. **Each \$37.50**

10% discount in lots of 6



86950

86950 GRATING SPECTROSCOPE, Cenco Design, Direct reading. Suggested originally by Professor Reinhard A. Wetzel of the College of the City of New York. The present design is a modification of the original device. A replica grating is employed through which light passes into the eye of the observer from an adjustable slit. The slit is illuminated by the light which is to be examined. The source of this light may be a spectrum tube or a flame colored with the salt of a metal or it may be a carbon arc or incandescent light when a continuous spectrum is desired. A spectrum is seen through the grating because of the fact that the latter produces as many images of the slit as there are wave lengths in the source of light. Each image appears on the wave length scale at the position which corresponds to its particular wave length. A window in the side of the spectroscopic case may be opened for illumination on the scale so that the wave length corresponding to any slit image may be read. The scale is bent on a curve which was computed to eliminate parallax between the slit images and the scale. The scale is graduated and figured to read $\text{cm} \times 10^{-5}$. Determinations of wave length may be made to the third significant figure with a fair degree of accuracy. A special holder is provided for spectrum tubes so that these may be secured directly to the instrument. An adjusting screw permits the width of slit to be varied up to approximately 1 mm. Because of the fact that the scale is enclosed in a light-tight compartment, no dark room is required. The scale is 18 cm long and the range is 3.8 to 8 $\text{cm} \times 10^{-5}$.

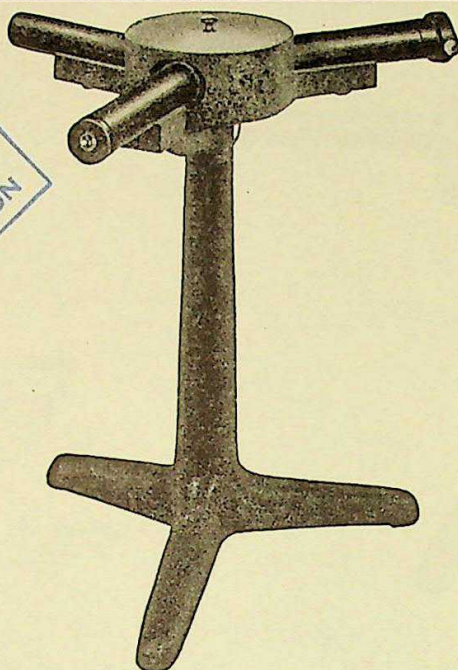
Among the suggested uses are the following:

1. **Spectroscopic analysis.** The position of each line being directly indicated, easy identification of substances by flame spectra is possible.
2. **Demonstration wave length spectrometer** of the grating type. The instrument illustrates to students the historical method of absolute wave length measurement originated by Fraunhofer.
3. **Measurement of wave length of light** in the student laboratory. The student can check the accuracy of the scale by measuring the distance between slit and grating, and the grating dis-

(Continued on next page)

LIGHT
Spectroscopes

PRICES CHANGED
WRITE FOR QUOTATION



86960

86950 GRATING SPECTROSCOPE, Cenco Design (continued from preceding page)

tance. With a source of light of known wave length, the deflection angle may be calculated and compared with the corresponding scale angle.

4. **Absorption band studies.** The liquid can be placed in a narrow tube held in the clips above the slit. The wave length scale gives direct readings of the absorption bands.

The price of this instrument, considering that it is both spectroscope and spectrometer, will commend itself as exceptionally low.....Each \$60.00

5% discount in lots of 3

For experiments employing this or similar apparatus see *Ham. Exp.* 512, p. 128; *White, Exp.* 71, p. 356. See list of Manual References, page 1000.

- 86952 Absorption Tubes, Grating Spectroscope**, for use with No. 86950 Grating Spectroscope and a source of light such as No. 85261 Illuminator. Set of 10 tubes as follows: 1. Potassium Permanganate (weak solution); 2. Potassium Permanganate (stronger solution); 3. Potassium Bichromate; 4. Iron Ferricyanide; 5. Nickel Nitrate; 6. Copper Sulphate; 7. Cobalt Chloride; 8. Chromic Acid; 9. Congo Red; 10. Fluorescein. In cardboard box with piece of ground glass and complete directions.....Per set 11.75

10% discount in lots of 6 sets

- 86960 SPECTROSCOPE, College Model, B & L**, a sturdy instrument of the Bunsen-Kirchhoff type producing a brilliant spectrum of about 12 mm length with very satisfactory definition. The resolving power is sufficient to effect separation of the two sodium D lines with little difficulty. These features, together with the low cost, exceptionally sturdy construction, and the fact that it is completely adjustable throughout, make this instrument especially suitable for student studies in charting the line and absorption spectra of various elements.

The telescope and collimator are equipped with achromatic objectives 22 mm in diameter and 125 mm focal length. The telescope is fitted with a Ramsden eyepiece of 18 mm focal length, which magnifies about 14 diameters. It is focused by a simple draw-tube adjustment. The telescope may be adjusted horizontally and its carriage locked in position by means of a conveniently located thumb screw. The slit is made of nickel-silver, carefully machined and fitted, with a delicate unilateral adjustment for width.

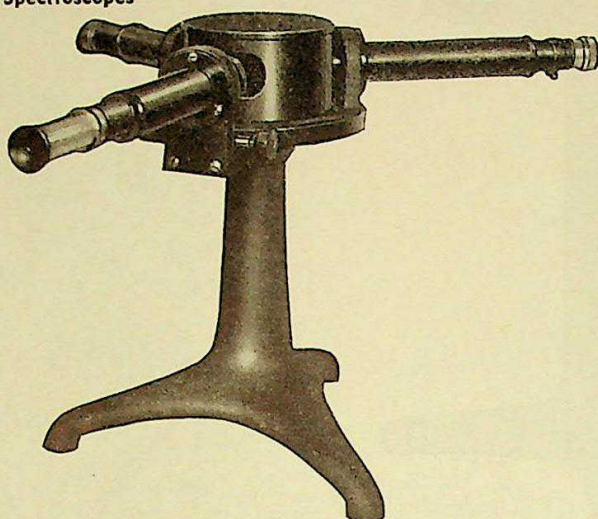
The scale tube is provided with a collimating lens and carries at the outer end a numbered scale and a ground glass diffusing screen. The scale, 15 mm in length, divided into tenths, provides an accurate arbitrary reference which is easily focusable adjacent to the spectrum. Since the relation between the scale and spectrum is fixed, the user may calibrate the scale in wavelengths by plotting the wavelengths of known spectral lines against scale readings.

The prism is securely clamped on the prism table by means of a strong spring clip and may be easily moved to the position of minimum deviation. The prism table can be adjusted precisely by means of three screws allowing the teacher to demonstrate the effect of moving the prism on the vertical plane. The prism, with 60° angles between each pair of polished faces, has a refractive index of approximately 1.65. The faces are 32x18 mm. The prism table is covered by a housing with removable top which encloses the prism and objective lenses, protecting these parts from dust and excluding stray light.

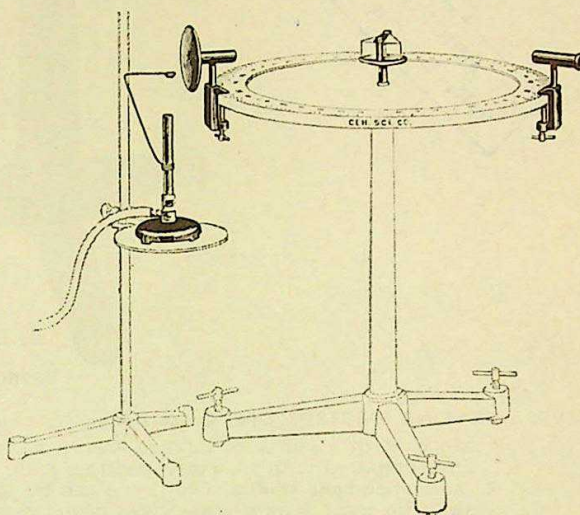
The pillar base is a metal casting finished in black wrinkle lacquer and forms a strong and steady support. Height to optical axis, 345 mm. Complete with prism.....Each 95.00

Bausch and Lomb Spectroscope Quantity Discounts, See Page 773.

LIGHT
Spectroscopes



86965



87005 shown in use on No. 74285 Force Table
(Described on next page.)

86965 SPECTROSCOPE, University Model, an instrument of the same type as No. 86960 but of larger dimensions and more rigid and sturdy construction. The telescope and collimator are larger and a prism of greater aperture is provided, thereby producing an instrument of increased magnification and better resolving power. The telescope is fitted with a screw fine adjustment for delicate rotation and is provided also with a fine vertical wire in the focal plane of the eyepiece to locate faint spectral lines for subsequent measurement, when the scale is illuminated. The spectrum from 400 to 800 μ is about 20 mm long in the focal plane of the eyepiece. This instrument is excellent for the detection and identification of the alkali metals in qualitative analysis.

The body of the instrument consists of a substantial iron table to which the collimator and scale tube are rigidly attached by flanges screwed to brackets, which are rigidly mounted on the body. The telescope is mounted on a movable bracket, which may be rotated about the axis of the instrument by means of a tangent screw providing a delicate motion over the entire spectrum. The body is supported upon a cast-iron tripod of graceful contour. The height of the instrument to the optical axis is 255 mm.

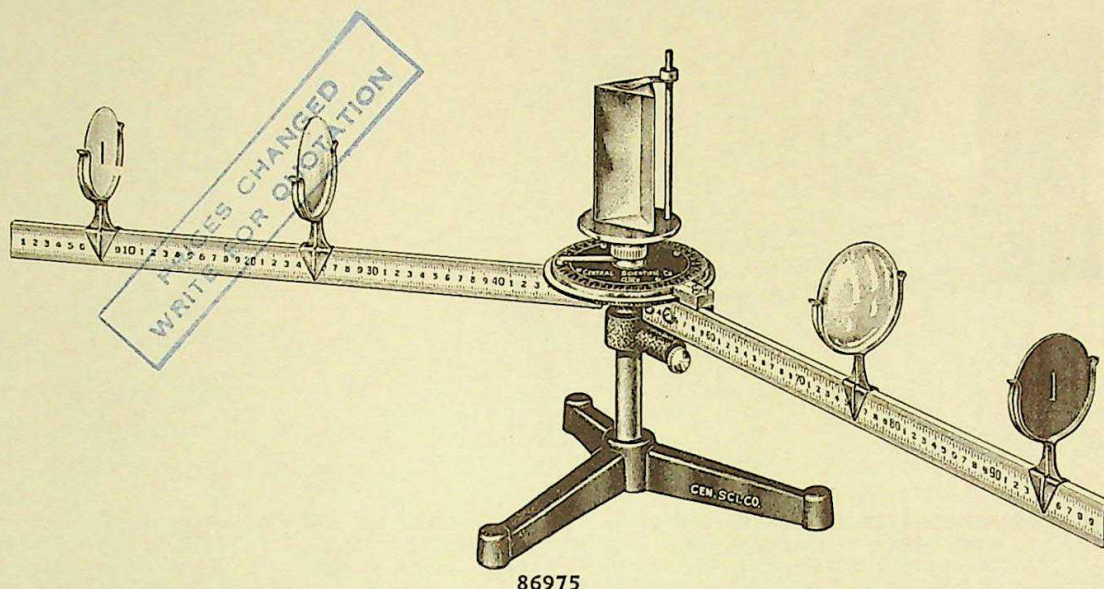
The telescope and collimator are equipped with high grade achromatic objectives of 25 mm aperture and 200 mm focal length. The telescope is fitted with a Ramsden eyepiece of 14 mm focal length. It is focused by a simple draw tube adjustment. A single vertical wire in the focal plane of the eyepiece permits the location of the position of a faint spectral line for subsequent measurement when the scale is illuminated. The collimator is fixed in focus to provide proper collimation and consistency of scale readings. The slit has carefully ground and polished nickel-silver jaws, 6 mm long, with a delicate unilateral adjustment for width.

The scale tube is mounted at the proper angle to secure full reflection from the face of the prism. It is provided with a collimating lens, a numbered scale and a ground glass screen. The scale is divided into 17 numbered parts, each of which is divided into tenths. The lines and figures of the scale appear light on a dark background.

The prism is securely clamped on the prism table in the position for minimum deviation, which is marked on the prism table. Leveling screws on the prism table permit adjustment, when required. The prism, with 60 degree angles, is of flint glass having a refractive index of $N_d = 1.65$. The faces are 38 by 22.5 mm. The dispersion is between 5 and 6 degrees for the spectral band from 400 to 800 μ . The prism table is covered by a housing which encloses the prism and objective lenses, protecting these parts from dust and excluding stray light.

Complete as described, with prism. Weight, approximately 10 lbs.....Each \$165.00

For experiments employing this or similar apparatus, see I. & M. Exp. 80, p. 271; Z. & E. Exp. 136, p. 248; D. C. M. Exp. 118, p. 271. See list of Manual References, page 1000.

LIGHT
Spectrometers

86975

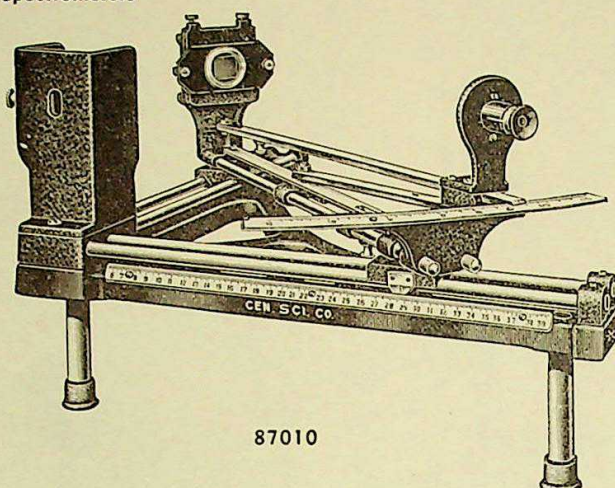
86975 SPECTROMETER, Cenco Elementary, McLachlan-Slingland Type, designed after suggestions by Professor Robert W. McLachlan and Mr. Charles E. Slingland for use in an elementary laboratory. The spectrometer is provided with a divided circle of 360° on which readings are taken opposite a single indicating line on the rotating arm on which the "telescope" is mounted. Angular readings may be estimated to 10 minutes. A prism table for holding prisms up to a length of 110 mm, or diffraction gratings, is mounted above the circle. The support rotates so that the prism may be turned relative to the "collimator" arm and the "telescope" arm. The "telescope" arm may be clamped in any desired position. The "collimator" and "telescope" arms consist of sections of a meter stick so secured to the instrument that the "collimator" arm is fixed at the 180° position with its end 50 cm from the center of the rotating table. The "telescope" arm of the same length, when turned to the zero position on the angular scale, is aligned with the "collimator" arm. Its end is also 50 cm from the center of the rotating table, so that the over-all length of the two aligned arms is 100 cm. The metric graduations on the two scales are consecutively numbered from 0 to 100, omitting those numbers at the center occupying the sections which have been removed for constructional reasons. Thus the two arms may be used for certain optical bench experiments, particularly those in which optical instruments are improvised from lenses.

The "collimator" and "telescope" of the spectrometer are made as follows: No. 85900 A or B Lens Supports are used for holding a selection of No. 85645 Double Convex Lenses and likewise for holding No. 86152 Combination Slit and Screen. In use, a No. 86152 Combination Slit and Screen is mounted in No. 85900B Support near the end of the "collimator" arm. A converging lens is so located, using a No. 85900 Support, that its principal focus is at the position of the slit. This renders rays of light from the slit parallel with the optical axis defined by the "collimator" arm. Instead of using a telescope with an eyepiece, it is found expedient and simple to use another double convex lens on the "telescope" arm and a No. 86152 Screen to receive the image. When the "collimator" and "telescope" are in alignment and the image screen is at the focal distance of the "telescope" lens, an image of the slit is formed on the screen. The spectrometer is then completed by putting a No. 85511 Prism on the prism table, holding it in position by means of the clamp.

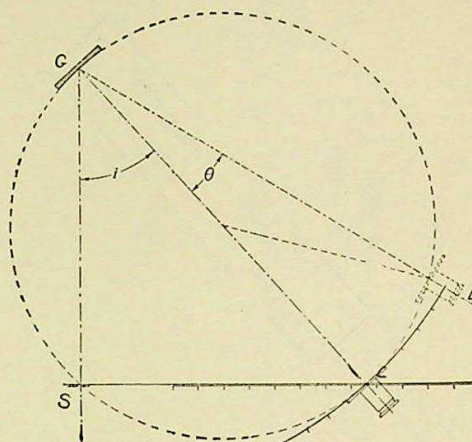
Spectrometer, only, **without** lenses, lens holders, screens or prism.....Each \$30.00
10% discount in lots of 6

87005 SPECTROMETER PARTS, for use with No. 74285 Force Table. These accessories are designed to be used in the assembly of a very simple form of spectrometer, of which the force table forms the nucleus. It follows the description given in Experiment 4, p. 83, of Zeleny and Erikson's "Manual of Physical Measurements." The simplicity of the arrangement—its freedom from complicated mechanical parts and adjustments—makes it particularly instructive. There are three parts which are attached to the force table: (1) a collimating tube with screen to cut off extraneous light; (2) a prism table which can be rotated in the axis of the force table; (3) a sighting tube with peep sight. The collimating tube and sighting tube are clamped to the rim of the force table, on the divided circle of which their angular positions may be read. A prism is placed on the prism table, and, with a sodium burner as a light source, the apparatus is ready for use. With prism table, but **without** prism, force table or sodium burner. (Illustrated on preceding page).....Per set 12.50
10% discount in lots of 6

LIGHT Spectrometers



87010



Schematic Diagram of 87010

87010 SPECTROMETER, Concave Grating, Rowland Mounting, Cenco, for measurement of wave lengths of visible light. The concave reflection replica gratings, Nos. 86886 to 86897, afford the instructor in optics a useful and instructive laboratory accessory. The price of a replica grating is lower than that of an original ruling, and the optical qualities of these replicas have been proved in many laboratories over a period of years. In the Cenco Concave Spectrometer, we offer the means for taking full advantage of the possibilities of the concave grating replica in visual work. The design is the development of a model Rowland mounting worked out by Dr. Ralph S. Minor, and used successfully by him in his optics laboratory. With Dr. Minor's apparatus, the student is enabled to study the relationship $m\lambda = \rho \sin i$, where m is the spectral order, λ the wave length, ρ the grating distance, and i the angle between the incident ray and the normal to the grating. In our design, it is possible in addition to experiment upon the general formula for the concave grating $m\lambda = (\sin i + \sin \theta)$, where θ is the angle between the normal to the grating and the line from the center of the grating to the spectral line corresponding to the wave length λ .

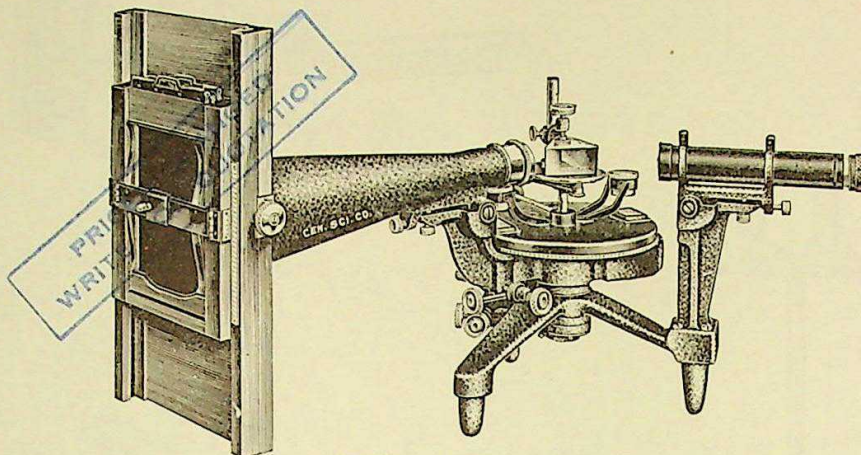
The Cenco Grating Spectrometer comprises a substantial base, with two mutually perpendicular ways on which the grating mount and the eyepiece slide, as in the usual Rowland arrangement. The grating mount and eyepiece are relatively fixed in position, by means of a bar of variable length, which permits adjusting the distance to the focal length of the grating which, according to the definition for concave gratings, is also the radius of the spherical reflecting surface of the grating. Incidentally, it also enables the instructor to put the apparatus out of adjustment, so that the student may learn by going through the preliminary operations necessary for making the measurements. The ways along which the eyepiece and grating slide consist of stainless steel bars. A linear scale is provided, at the zero point of which the slit is located. The scale reading at any setting of the eyepiece, divided by the distance from the grating to the crosshairs, is the sine of the angle i , which appears in the simplified formula. Associated with the tie-bar between grating and eyepiece is a link arrangement which, at any particular setting—say normal at $\lambda 4800$ in the second order—enables the student to swing the eyepiece along the Rowland circle and examine the entire spectrum. The eyepiece is kept pointing automatically at the center of the grating. An engine-divided circular scale gives him the value of θ for any angular setting. A locking device permits use of the eyepiece in the normal position only if this is desired, as in studying the simple formula first given. In this case a setting may be made on any particular line, say $\lambda 5461$ of mercury, in each of the three orders, and the linear scale reading obtained. This brief description of the possibilities will suggest to the instructor the variety of experiments to which this apparatus is adaptable.

The grating mount is designed for all necessary adjustments to the grating, and it will securely hold any one of the concave gratings listed under Nos. 86886 to 86897. Gratings of 42.5 cm focus should be specified, since the spectrometer can be used with no other. An especially selected No. 86886A Grating of 425 mm focus is supplied with the instrument. A mask is furnished with the grating to expose only the grating area from which the best result may be secured. The slit is of stainless steel, with adjustments for width and parallelism with the rulings of the grating.

By making settings on two lines of known wave length in each of the three orders, straight-line calibration curves may be drawn in cross-section paper from which any wave length may be immediately ascertained in terms of the linear scale. Likewise three linear graphs in terms of degrees on the circular arc may be constructed. The accuracy of measurement in the second order is ± 2 Angstrom units. With selected grating and mask.....Each \$225.00

5% discount in lots of 3

For experiments employing this or similar apparatus see D. C. M. Exp. 114, p. 251; M. & W. Exp. 11, p. 41; S. E. P. L55b. See list of Manual References, page 1000.

LIGHT
Spectrometers

87020 with 87026 Attached.

87020 SPECTROMETER, Spencer, Student Model, designed to provide an instrument of an accuracy well within the requirements of advanced physical laboratory work, yet so ruggedly constructed that it will withstand unskilled handling in student use. The support arms for the telescope and collimator hold these parts rigidly in perfect alignment and have incorporated in them a vertical tilt adjustment, which locks by means of a clamping screw to make the adjustable part integral with the support arm. The central bearings, which are the heart of the spectrometer, are massive enough to withstand continuous service for an indefinite period of time. The clamps for the telescope and prism table are of a design that prevents creeping during adjustment. The slow motion screws are carefully lapped to operate smoothly.

The prism is adjustable for height and is provided with leveling screws. The 5-inch circle is graduated to 30 minutes on a brass disk that has been tempered to prevent warping. The verniers, mounted 180 degrees apart and rotating on the same level as the circle graduations, permit readings to single minutes of arc. The method of mounting and the close fit of the circle and verniers allows them to be read easily and rapidly without errors of parallax. The circle and verniers are enclosed in a dust tight cover having glass windows through which the verniers can be read by means of magnifiers held conveniently above them.

The optics of this instrument are of the finest quality. The telescope and collimator have one-inch achromatic objectives which have a focus of six inches. These dimensions insure more illumination than is usually needed. The telescope eyepiece is of the usual Gauss type having a focus of one inch. The magnification of the telescope is, therefore, six diameters. The eyepiece is arranged for focusing and has an opening in the side with reflector for illuminating the cross hairs. The collimator is 150 mm long and is provided with a support for the attachment of No. 87022 Comparison Prism. The optics of the collimator form a sharply defined image of the slit, which is adjustable by means of the knurled ring on the end of the collimator. The slit is formed between two plates of metal, carefully ground to knife edges, which move symmetrically from the center and remain perfectly parallel at all openings.

As described, but **without** prism, prism clamp, comparison prism or grating clamp. **Each \$253.00**

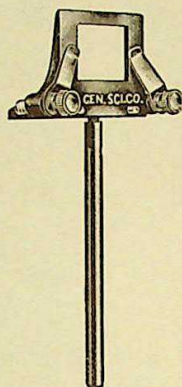
For experiments employing this or similar apparatus see I. & M. Exp. 79, p. 267; Ham. Exp. 509, p. 122; White Exp. 67, p. 338; Rich Exp. 61, p. 204, Exp. 62, p. 208; Z. & E. Exp. 2, p. 92, Exp. 10, p. 95, Exp. 11, p. 96, Exp. 12, p. 97, Exp. 13, p. 98; T. W. & H. Exp. 44, p. 123, Exp. 51, p. 143; Min. Exp. 94, p. 120, Exp. 95, p. 124, Exp. 104, p. 160; Tay. Exp. 5, p. 62; Exp. 6, p. 77, Exp. 7, p. 88; D. C. M. Exp. 106, p. 225, Exp. 107, p. 230, Exp. 108, p. 234, Exp. 113, p. 250; D. & S. Exp. 142, p. 595, Exp. 143, p. 600; M. & W. Exp. 3, p. 9, Exp. 9, p. 33, Exp. 10, p. 37; S. E. P. L52b, L53b.

87022 Comparison Prism, for attachment to the collimator of No. 87020. **Each 13.00**

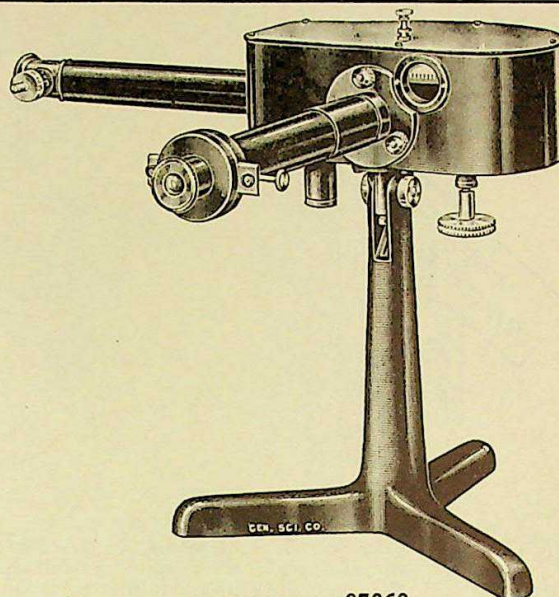
87024 Prism Clamp, for use with No. 87020 Spectrometer to hold the prism securely in the desired position. **Each 5.00**

87026 Camera Attachment, for converting No. 87020 Spectroscope into a spectrograph. The camera is interchangeable with the telescope of No. 87020 and may be adjusted with the same degree of precision. The lens has a free aperture of 25 mm and a focal length of 300 mm. It is focused by means of a graduated draw tube to produce a sharp image on the ground glass screen, which is interchangeable with the plate holder. A slide is provided for shifting the plate up and down, making it possible to obtain a series of exposures on one plate. The position of the plate may be determined by means of an index and vertical scale. The frame carrying the plate holder is pivoted in the center and provided with a bellows, so that the plate can be inclined to focus sharply on the different lines of the spectrum. A single plate holder for 6.5 by 9 cm plates is supplied with the camera. By means of a No. 87022 Comparison Prism, comparison spectra may be photographed together with the spectra under investigation. **Without comparison prism. Each 95.00**

Spencer Spectrometer Quantity Discounts, See Page 773.

**LIGHT
Spectrometers**


87050 shown on No. 72162 Rod



87060

- 87050 HOLDER, Mirror and Grating**, for supporting mirrors or gratings either on a spectrometer table or in an optical bench. Consists of a cast mounting with two faces at right angles machined smooth. One of them has a square aperture about 30x35 mm and is provided with spring clips to support objects up to 50x50 mm. The other surface is used as the base. It has a threaded hole for a standard $\frac{3}{8}$ inch (10 mm) rod. **Each \$4.60**

10% discount in lots of 6

- 87055 Spectrometer Prisms**, for No. 87020 Spectrometer, with 60° angles between each pair of polished faces. Refractive index is approximately 1.65. For maximum resolving power and maximum intensity of spectrum, we advise the purchase of the size C prism.

No.	B	C
Height, mm	18	22.5
Length of side, mm	36	45
Each	13.00	20.00

10% discount in lots of 5

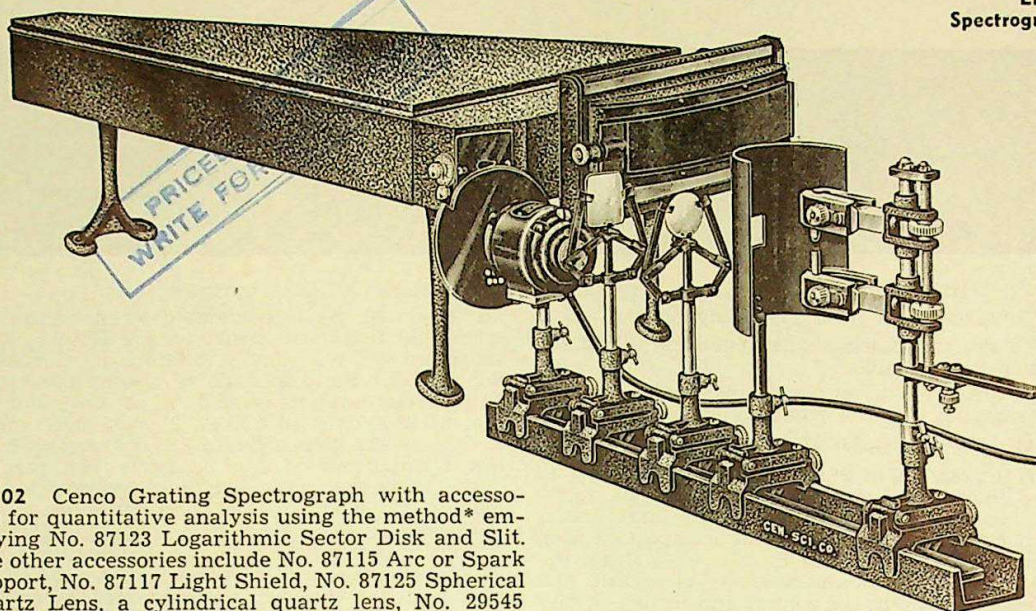
- 87060 SPECTROMETER, Wavelength Scale, Constant Deviation Prism**, for direct measurement of the wavelengths of spectral lines in millimicrons from a graduated drum. A single adjustment, that of turning a knurled head beneath the prism housing, brings the desired portion of the spectrum into the field of the eyepiece and indicates its wavelength on the graduated scale, which is observed through a window in the prism housing at the right of the viewing telescope. The graduations on the 249 mm scale are in steps of $m\mu$ from 400 to 600, in steps of 2 $m\mu$ from 600 to 650, and in steps of 5 $m\mu$ from 650 to 800. From 400 to 500 every fifth step is numbered and from 500 to 800, every tenth step. The scale is adjusted to agreement with the prism by setting the former on the reading for the sodium line and pressing the stop on the top of the housing to hold it in this position while the prism is rotated until the sodium line coincides with the eyepiece cross hair.

The constant deviation prism is of the Pellin-Broca type and is made of a single piece of flint glass of high dispersion. The vertical surface, upon which the light is incident, is 22 mm in height and 45 mm in width. This prism is securely fixed to the prism table, which is rotated by a cam attached to a vertical shaft. The shaft extends through the bottom of the housing and has a knurled head at its lower end. At the other end of the shaft, above the cam, is a drum 102 mm in diameter, which carries the graduated scale. A dust-proof housing with removable cover plate encloses the prism, its operating mechanism, and the graduated drum. The telescope and collimator are permanently aligned at right-angles to each other. This construction is made possible by the fact that the constant deviation prism, however rotated, reflects the spectrum lines at a constant angle of 90 degrees. The standard of the instrument is provided with an inclination joint to permit the telescope to be tilted to any convenient angle for viewing or adaptation to other instruments.

The collimator is equipped with an adjustable slit, the width of which is controlled by means of a micrometer screw with graduated head reading to 0.1 mm; the length is controlled by a V-slide close to the face of the slit. The slit jaws are non-corroding stellite, an extremely hard alloy that permits grinding to sharp, clean edges. A comparison prism, by which auxiliary spectra may be introduced into half of the field, is incorporated in the slit mounting.

The telescope has an aperture of 20 mm and equivalent focus of 162.6 mm. The objective is movable along the optical axis by a sliding collar surrounding the body tube. The eyepiece magnification is 14x. The eyepiece holder is equipped with the cross hairs and a shutter. The shutter provides for the suppression of parts of the spectrum not under observation, and permits the apparatus to be converted into a monochromator by removing the eyepiece. The shutters are operated by push rods extending through the sides of the casing.

Complete as described, with prism, adjustable slit, eyepiece shutter with cross hairs and 20 mm E.F. eyepiece, but **without** scale illuminator. **Each 490.00**

LIGHT
Spectrographs

87102 Cenco Grating Spectrograph with accessories for quantitative analysis using the method* employing No. 87123 Logarithmic Sector Disk and Slit. The other accessories include No. 87115 Arc or Spark Support, No. 87117 Light Shield, No. 87125 Spherical Quartz Lens, a cylindrical quartz lens, No. 29545 Illuminating System Bench and No. 85804 Carriages.

SPECTROGRAPHIC ANALYSIS

The steadily increasing use of spectrographic methods of analysis may rightly be considered one of the more significant recent developments in the fields of chemistry and physics. A review of current issues of scientific publications clearly indicates the growing importance of the spectrograph in industry and in laboratories of educational and government institutions. Meggers and Scribner, in their *Index to Literature in Spectrochemical Analysis*,† have shown that more than ten times as many papers on the subject were published from 1932 to 1937 as during 1920 to 1925. The importance of the spectrograph is further indicated by the establishment, in growing numbers, of courses in spectrography in colleges and universities. Several recent text books have been designed for college use.°

Reasons for this increasing interest are clear, and may be briefly stated. As compared with usual chemical procedures, the use of the spectrograph in the analysis of unknowns for their metallic constituents generally results in a substantial saving of time. When the percentages sought are small, the accuracy is usually greater than that possible by any other method. Quantities smaller even than those required in gravimetric and other kinds of microchemical analysis can be reliably determined. It is obvious, therefore, that an attempt to enumerate all possible applications of the spectrograph would make an enormous list. A number of specific uses will, however, be mentioned.

Qualitative analysis with the spectrograph is possible over the entire range of concentrations suitable for chemical analysis. It is often superior to chemical analysis of the same material in that unsuspected elements are as readily revealed as

those thought to be present. In addition, it reveals the presence of metals at concentrations so low that they would escape chemical detection. Spectrographic analysis also saves time since all elements present in the sample usually can be detected by a single exposure.

Quantitative analysis with the spectrograph is most satisfactory when concentrations are, roughly, below 5%. Above this, chemical methods may be better. Below 0.1% the spectrographic method has marked superiority. Indeed, often it is the only method which will give reliable results when the concentrations are this low.

An excellent summary of the applications and advantages of the spectrograph as an analytical tool is given by Professor George R. Harrison, Director of the Eastman Research Laboratory of Spectroscopy, Department of Physics, Massachusetts Institute of Technology, as follows:

1. To tell what metallic elements are present.
2. To watch the progress of a chemical purification.
3. To watch the progress of a chemical analysis.
4. To analyze a substance when only a minute quantity is available; for example, 2 mg, as against 200 mg to 1 g for chemical analyses.
5. To detect unsuspected metals.
6. To detect very minute quantities of an impurity.
7. To obtain a permanent record.
8. To examine substances difficult to attack chemically, such as glasses, slag, refractories, and certain organic materials.
9. To determine the nature of inclusions in minerals and alloys.
10. To differentiate between two substances very similar chemically, such as Nd and Pr.

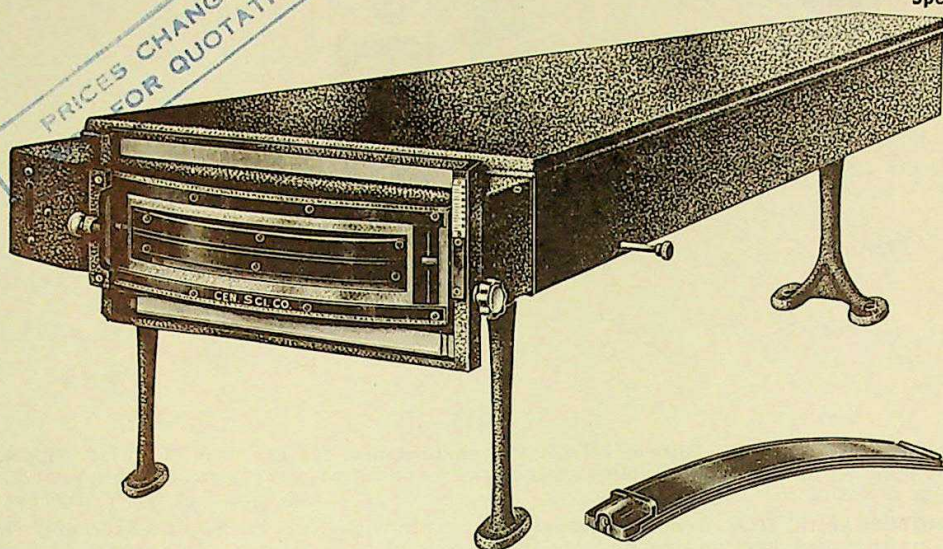
(Continued on next page)

*Sullivan, H. M., *Ind. Eng. Chem., Anal. Ed.*, 8, 382 (1936).

†Published by the American Society for Testing Materials, Philadelphia, 1939.

°Sawyer, "Experimental Spectroscopy" (1944), Prentice-Hall, Inc., New York.

°Harrison et al., "Practical Spectroscopy" (1948), Prentice-Hall, Inc., New York.

LIGHT
Spectrographs

87102 with film holder removed

87102 GRATING SPECTROGRAPH, Vertical Racking Film Holder, Cenco, for making first order spectrograms, 25 cm in length, between the limits of 2350 and 7000 angstroms. The dispersion of the instrument is approximately 16 angstroms per mm throughout the wave length range. By rotating the grating, any 4000-angstrom portion of the spectrum within the limits mentioned may be photographed with a single exposure. A light-tight housing permits photography of the spectra outside a dark room.

The spectrograph is made with a cast aluminum housing finished in black wrinkle enamel and supported upon three substantial, cast metal legs. A loose-fitting cover, finished to correspond with the housing, permits easy access to the interior. The slit, at one end of the housing, is of stainless steel and is adjusted by two knurled screws, one for slit width and the other for slit parallelism with the grating lines. The grating for producing the spectrum is located within the opposite end of the housing. It is a concave reflecting grating of the replica type, having 15,000 lines per inch and a focal length of 106 cm. The grating holder is fitted with adjusting screws for rotating the grating about the three principal axes and shifting it laterally. The grating is properly masked to expose the maximum portion of the ruled area that will give well-defined spectrum lines.

The instrument has an aperture 16 mm wide, and is supplied with two slotted masks having 2 mm and 4 mm openings respectively. The former makes possible the photographing of 14 spectra on a single film and the latter provides for 6. The 16 mm aperture is required for use with the No. 87123 Sector Disk. The film holder, or camera, located on the housing at the right of the slit, is curved to coincide with the radius of curvature of the grating where all images of the slit are in sharp focus. It takes Nos. 87109 and 87107 Films, which are 2½ inches wide by 11¼ inches long.

A rack-and-pinion adjustment is provided for shifting the film holder vertically along a scale graduated and numbered for the 14 positions of exposure. By shifting the film, the same portion of the light source is used for each exposure. In quantitative analysis, where reproducibility of conditions is important, this feature is highly desirable. Over-all dimensions: length, 46½ inches; width, 21½ inches; height, 13¾ inches. Complete with grating, camera, and aperture masks, but **without** other accessories or film.....**Each \$500.00**

5% discount in lots of 3

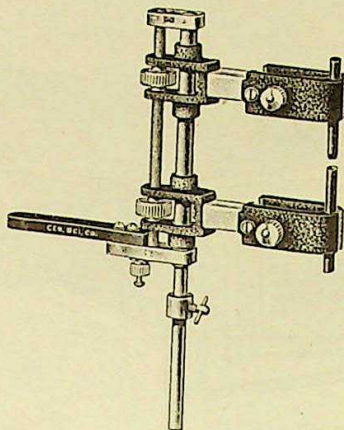
87106 RECTIFIERS, Carbon Arc Power Supply Units, Mellaphone, for use with No. 87102 Grating Spectrograph, in conjunction with No. 87115 Arc Support and Nos. 87135 and 87136 Spectrographic Carbons to supply the necessary 230 volt D.C. current from A.C. sources. These consist of single phase, full wave rectifiers, using two mercury vapor tubes as rectifying elements. High efficiency, high power factor, excellent voltage regulation and low maintenance through the extremely long life are provided. Transformers are insulated to withstand the standard Underwriter's test of twice rated voltage plus 1000 volts. This insures long and trouble-free life. Provided with high, medium and low line voltage adjustment taps. Housed in properly ventilated steel cases for floor or wall mounting.

Nos. A and B have transformers of the insulated primary-secondary type and use No. HW-6 mercury vapor tubes. No. C has an auto-transformer and uses No. HW-15 mercury vapor tube. The heavy duty mercury vapor tubes of No. C are externally mounted in a perforated metal grill. For use on 60 cycle current only. Complete with mercury vapor tubes, connecting cord and plug.

No.	A	B	C
Input, volts A.C., 60 cycle.....	115	230	230
D.C. output, volts.....	230	230	230
D.C. output, amps.....	10	10	20
Each	184.00	184.00	345.00

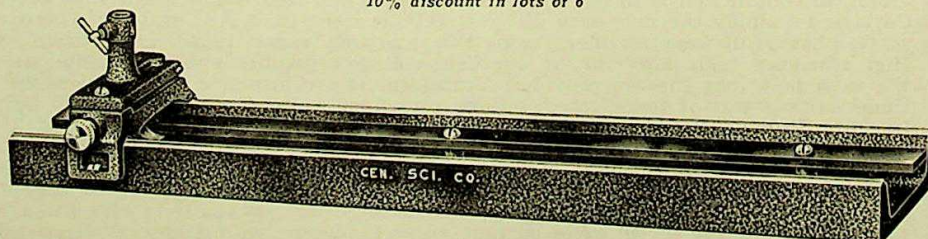
LIGHT

Spectrograph Accessories



87115

- 87107 **PHOTOGRAPHIC FILM**, Eastman's Tri-X Pan, Antihalation, for use with No. 87102 Spectrograph in photographing the red, yellow, green, violet and ultraviolet regions of the spectrum. Packed in boxes of 25.....**Per box \$3.75***
- 87109 **PHOTOGRAPHIC FILM**, Eastman's Commercial, for use with No. 87102 Spectrograph in photographing the ultraviolet and near ultraviolet regions of the spectrum. This film is recommended for most work in analytical spectrography. Packed in boxes of 25.....**Per box 3.15***
- 87111 **Camera**, only, of No. 87102 Spectrograph. An extra camera is often a useful accessory..**Each 27.00**
10% discount in lots of 6
- 87112 **FOCUSING EYEPIECE**, Spectrograph, for use in the camera slots of No. 87102 Spectrograph to assist in focusing the grating and to observe lines in the visible portion of the spectrum. Consists of a metal plate holding a tubular slide mounting which contains a lens with cross-wires**Each 14.00**
10% discount in lots of 6
- 87113 **WAVELENGTH SCALE**, printed on bristol board, for measuring the wavelengths of spectrum lines on spectrograms. Reads directly in wavelength units.....**Each .65**
10% discount in lots of 12
- 87114 **ILLUMINATING SYSTEM BENCH**, same as No. 29545 Bench, but 125 cm long and without No. 85804 Carriage. For use with No. 87102 Spectrograph.....**Each 25.50**
10% discount in lots of 6
- 87115 **ARC OR SPARK SUPPORT**, Spectrograph, Cenco, for supporting carbons or metal rod samples, between the ends of which an arc or condensed spark may be struck, to illuminate the slit of No. 87102 Spectrograph.
The support is made with machined metal jaws so massive that they will easily carry operating currents of 20 amperes at 230 volts. The clamping arrangement of the jaws is designed for lateral adjustment of the rods, so that they may be perfectly aligned. Each jaw assembly is mounted on an insulant block that effectively insulates as high as 25,000 volts. Even spark voltages are thus confined to the clamp assemblies. The carbons or specimen rods are both adjustable vertically by means of knurled nuts operating on a quadruple screw. As an additional safeguard to the operator, a binding post is provided for connection of a ground wire. The assembly may be swung about the rod mounting in the horizontal plane by means of an insulated handle. An adjustable collar on the mounting rod permits free lateral rotation without change in elevation of the position of the arc or spark. The rod below the mechanism is $\frac{3}{8}$ inch in diameter and fits Nos. 85802 and 85804 Bench Carriages and No. 72202 Support Stand. The use of a No. 87116 Control Panel is recommended for easy adjustment of operating current to optimum working values.
Complete, as described, but without carbon or metal rods, control panel, bench carriages, or support stand**Each 33.00**
10% discount in lots of 6



29545

- 29545 **ILLUMINATING SYSTEM BENCH**, for supporting the light source, either arc or spark, and optical system in proper alignment with No. 87102 Spectrograph. The bench is 60 cm long, and is provided with holes for securing permanently to a table by means of screws. With 1 No. 85804 Carriage, but without arc or spark support, light shield or lens holders.....**Each 13.75**

*Federal excise tax extra, if applicable.

LIGHT
Spectrograph AccessoriesPRICES CHANGED
WRITE FOR QUOTATION

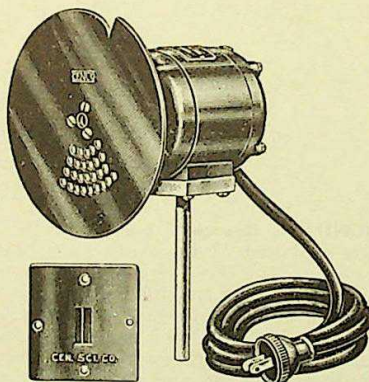
87117

- 87116 ARC CONTROL PANEL**, for controlling, from 2 to 10 amperes, the current supplied to No. 87115 Support when the latter is used as a D.C. Arc. Consists of three water-cooled rheostats, reactors, switches and binding posts in a convenient arrangement on an insulating panel, with brackets for wall mounting. Width, 20 inches; height, 24 inches.....**Each \$115.00**

5% discount in lots of 3

- 87117 LIGHT SHIELD**, for use in front of No. 87115 Arc or Spark Support on Nos. 29545 and 87114 Benches, in a No. 85802 Hinged Carriage, which will permit swinging the shield out of position when the light source is being adjusted. Consists of a black-finished, curved metal shield with aperture and support rod for attachment to carriage. **Without carriage..Each 2.80**

10% discount in lots of 6



87123

- 87123 LOGARITHMIC SECTOR DISK AND SLIT**, for use with No. 87102 Spectrograph and accessories in quantitative spectrographic analysis according to the method described by H. M. Sullivan in *Ind. Eng. Chem., Anal. Ed.* 8, 382 (1936).

The sector disk is mounted on the shaft of a split-phase motor which operates at a speed of approximately 1725 R.P.M. A rod for mounting in a No. 85804 Carriage is attached to the motor base.

The rotating sector is cut from a disk of 75 mm radius and reduces the light intensity logarithmically so that the lengths of the spectrum lines are proportional to the intensity of the light. A fixed slit approximately 14 mm long and 0.1 mm wide is supplied with the disk. In use, it is mounted on the spectrograph in front of the adjustable slit. Complete, with slit, connecting cord and plug, and motor for 115-volt, 60-cycle A.C., but **without carriage.....Each 46.50**

10% discount in lots of 3

- 87125 QUARTZ LENS, Spherical, Double Convex**, for use on Nos. 29545 and 87114 Benches in focusing light on the slit of No. 87102 Spectrograph. Transmits wave lengths in both the ultraviolet and visible regions of the spectrum. May be held in place with a No. 72288 Lens Holder and No. 85802 Carriage. Made of fused quartz, ground and polished. Diameter, 4 cm; focal length, 14 cm $\pm$ 2 mm.....**Each 15.50**

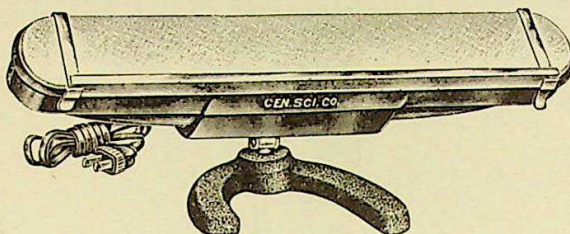
10% discount in lots of 6

- 87126 QUARTZ LENS, Spherical, Double Convex**, same as No. 87125 Lens, but with focal length 10 cm $\pm$ 2 mm.....**Each 21.50**

10% discount in lots of 6

LIGHT

Spectrograph Accessories



87130

87130 VIEWING LIGHT, Cenco, for illuminating spectrograms, lantern slides, photographic transparencies, etc., for examination or measurement of detail. It holds sixteen 2x2-inch Kodachrome transparencies, which gives it great utility in the sorting or selecting of such slides. The illumination is of approximate daylight quality and is diffused by a white translucent plate for uniformity over an area 18½ inches long by 2⅝ inches wide.

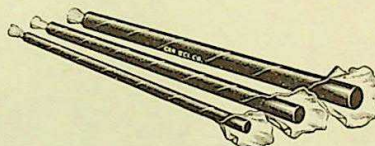
Consists of a tubular fluorescent mercury arc lamp, which emits a diffuse light approximating daylight, with fixture, containing the current controls, and a sloping translucent stage, with rail along the lower front edge to support the objects under examination. The light is designed for operation from 115-volt, 60-cycle current sources. It may also be operated on a 115-volt direct current in series with a 50-watt tungsten lamp, but the polarity must be kept the same throughout the life of the lamp. Dimensions: length over-all, 19 inches; width of base, 7 inches; depth of base, 6 inches; height, over-all, 6⅛ inches. Length of tubular lamp bulb, 18 inches. Complete, with No. 87281 Bulb and rubber-covered connecting cord with attachment plug.....

Each \$20.00

10% discount in lots of 6



87131



87135-87136

87131 SPECTRUM MEASURING MAGNIFIER, Bausch & Lomb, for the examination of spectrograms and for the measurement of the positions of spectrum lines with reference to other lines in the same or adjacent spectra.

Consists of a high grade triple aplanatic magnifier mounted in a focusing sleeve which screws into a cylindrical barrel to the bottom of which is attached a metal flange carrying a glass disk. On the under side of the disk is ruled a scale, 20 mm long, each millimeter being numbered and divided into tenths. The lens gives a magnification of 6.5X. The field is perfectly flat and free from chromatic aberration and distortion.

In use, the magnifier is set directly on a spectrogram, which should be illuminated from the back, preferably with a No. 87130 Viewing Light. For the quick identification of lines and measurements of moderate accuracy, the magnifier is a great time-saver.....

Each 20.00

87135 SPECTROGRAPHIC CARBONS, Certified Grade, especially purified to produce high intensity illumination for precise spectrographic analyses of materials. The carbon is processed at low temperature and at atmospheric pressure, resulting in a well-bonded electrode of uniform density and exceptionally low content of impurities. Complete with a laboratory certificate showing the actual spectrographic analysis of the impurities present. Length of carbons, 12 inches; individually wrapped in cellophane, in boxes of 12 rods.

No.	A	B	C
Diameter, inches	3/16	1/4	5/16
Per box	14.52	15.84	18.48

10% discount in lots of 12 packages

87136 SPECTROGRAPHIC CARBONS, Spectrochemical Grade, a high grade carbon processed to meet most spectrographic requirements, but furnished **without** the certificate of analysis. While these rods do not meet the same rigid tolerances of the Certified Grade, they are purified by the same process and are desirable for most spectrochemical work where relatively slight traces of a few impurities do not interfere. These are recommended for routine analyses. Length, 12 inches; individually wrapped in cellophane in boxes of 12 rods.

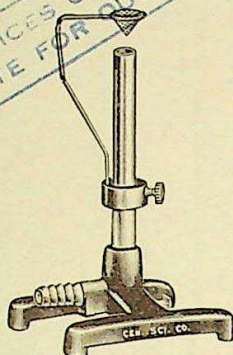
No.	A	B	C
Diameter, inches	3/16	1/4	5/16
Per box	9.24	10.56	13.20

10% discount in lots of 12 packages

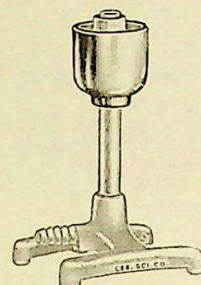
Bausch and Lomb Magnifier Quantity Discounts, See Page 773.

LIGHT
Monochromatic Burners

PRICES CHANGED
WRITE FOR QUOTATION



87165



87175 shown in use

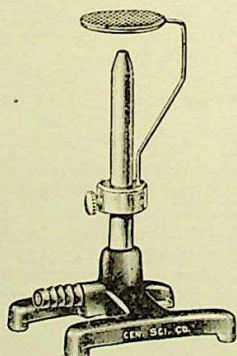
- 87165 MONOCHROMATIC FLAME BURNER, Cenco, according to Zeleny and Erikson, consisting of No. 11002 Cenco Bunsen Burner and a substantial holder of Chromel wire, coiled at its upper end in the form of a small cup to hold the salt for coloring the flame.

No.	A	B	C
For use on, gas.....	Artificial	Mixed	Natural
Approx. gas Btu.....	500-550	750-850	1050-1150
Each	\$3.15	3.15	2.80

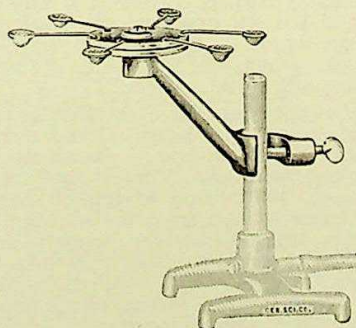
10% discount in lots of 6

- 87175 MONOCHROMATIC FLAME ATTACHMENT, for Bunsen burners. The reservoir, which slips over the top of a burner stack, is provided with an asbestos wick at the center. This wick surrounds the mouth of the burner closely and feeds up to the flame any solution placed in the reservoir. The flame is continuously colored while the solution lasts. For any burner with $\frac{1}{2}$ -inch tube. Without burner.....Each 2.15

10% discount in lots of 6



84730



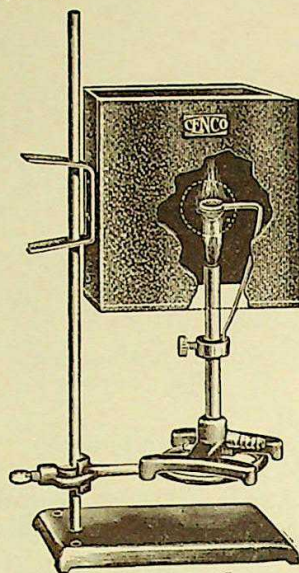
87180

- 84730 MONOCHROMATIC FLAME BURNER, Cenco, consisting of a special burner with opening of very small diameter, producing a needle-shaped flame which heats the salt used to color the flame. The salt is placed on a Chromel wire gauze, which is clamped to the burner tube and may be adjusted to the proper height to secure best results. This is a convenient and practical apparatus for producing a monochromatic flame in the physics laboratory. The Chromel wire gauze can be cleaned with hot water or dilute acid after use, but it is preferable to employ several burners, confining the use of each one to a given salt.....Each 4.15

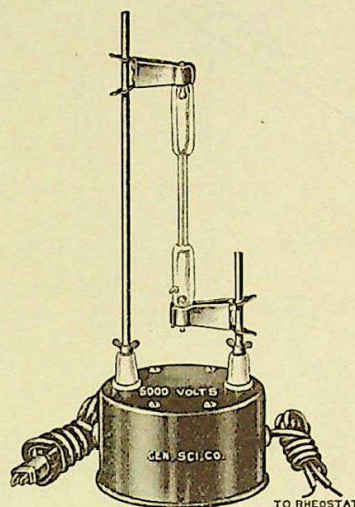
- 87180 MONOCHROMATIC FLAME ATTACHMENT, Cenco-Harcourt, for attachment to any laboratory burner with a vertical tube diameter not greater than $\frac{5}{8}$ inch. Six arms of chromel wire are provided with small chromel gauze pockets to hold salts of various metals from which flame spectra may be obtained. The arms are mounted so that any one of them can be rotated into position in the flame of the burner. On the mounting plate opposite each arm the name of the salt may be written. Without burner.....Each 6.00

10% discount in lots of 6

LIGHT Spectra Apparatus



87200



87208

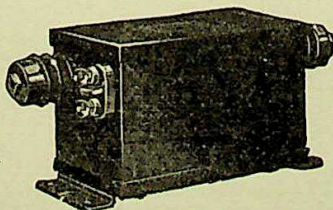
- 87200 SODIUM BURNER, Cenco Improved Type**, for use as a monochromatic light source in optical experiments. Consists of a No. 11027C Burner mounted on a No. 18000C Support Ring. A No. 12240 Clamp permits vertical adjustment of the burner on the support rod. The small chromel gauze container for fused sodium chloride is adjustably attached to the burner tube. The light shield with a window on the side screens extraneous light from the surroundings but gives a view of the flame in the direction desired. The burner may be used on either mixed or natural gas. Approximate dimensions: height to top of rod, 41 cm; area of base, 12 x 19 cm; shield, 9 x 16 x 16 cm. Complete with stand, burner, clamp, ring and shield, but **without** rubber tubing for gas connection.....**Each \$11.25**

10% discount in lots of 6

- 87208 SPECTRUM TUBE POWER SUPPLY**, for operating Nos. 87210 to 87265 Pluecker Spectrum Tubes from usual lighting circuit to give steady illumination of maximum brightness consistent with a satisfactory operating life. The character of illumination is superior to that secured with usual battery operated spark coils, and danger of injury to tubes from excessively heavy discharges is avoided. Adjustable tube clamps on the high potential rod-terminals provide the means for conveniently supporting the spectrum tube in front of the slit of the spectroscope or spectrometer.

The power supply consists of a special transformer suitably mounted within a metal housing from which the high potential rod-terminals rise through heavy porcelain insulators. Each rod-terminal carries a spring clamp of such dimensions that the spectrum tube is firmly held by its metal terminals. The clamps are easily moved on the rods when the rod clips are compressed. In addition to the attachment cord for the service outlet, a pair of rubber-covered leads extend from the housing for connection of a rheostat, such as a No. 82910-12 Slide Wire Rheostat, to the primary circuit to provide a means for controlling the intensity of illumination from the spectrum tube by variation of the current to the transformer. For operation from 115-volt, 50/60-cycle A.C. Output current, 18 milliamperes at 5000 volts. Height, over-all, 16 $\frac{3}{4}$ inches. With five-foot, rubber-covered connecting cord with attachment plug, but **without** spectrum tube or rheostat**Each 20.00**

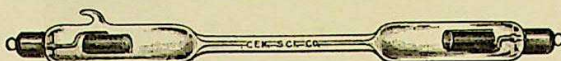
10% discount in lots of 6



80365A

- 80365A TRANSFORMERS, High Voltage**, for use as a source of high potential in special applications. The design is such that the secondary may be short-circuited without damage. Especially designed for gas tube service such as lighting neon tubes. Complete with 6-foot cord with attachment plug and two high voltage leads. For use on 115-volt, 60-cycle A.C. only. Rated output, 18 milliamperes at 2000 volts. Power demand, 50 watts.....**Each 8.70**

J150

LIGHT
Spectrum Tubes

87210-87265

SPECTRUM TUBES (Pluecker Tubes)

We offer a complete selection of these tubes which are designed for use as light sources with spectroscopes and wavelength spectrometers for acquainting the student with the spectra of various gases and for having him determine the wavelength of certain characteristic lines. They will also find use as standards of reference in examining the spectra of unknown gases and vapors to determine their constituents. They will be found especially useful in the student laboratory of physics in connection with our No. 86950 Grating Spectroscope with which the entire spectrum of any substance can be viewed at one time.

The gas contents of these spectrum tubes have been highly purified so that in most cases the spec-

tra are free from lines due to other substances. The narrow portion of the tube is a thick-walled capillary tube which concentrates the luminescence in a narrow column of maximum intensity.

The electrodes are of the proper area to withstand the heat produced by using the tubes on an ordinary 1-inch spark coil, like No. 79800, when the primary is excited by a current only large enough to produce a spark of 8 to 10 mm from the secondary. They are welded to platinum wires which are firmly sealed through the glass. The tubes are provided with metal caps cemented on, to which external connections are made. All tubes are 25 cm in length with the capillary portion about 8.5 to 10 cm.

Note: In order to minimize the danger of injury to the tubes due to heavy spark discharge, it is suggested that No. 79800 or any other small induction coil be adjusted to provide a thin spark from not more than two or three dry cells.

87210	Spectrum Tube, Argon Gas	Each \$3.50
87215	Spectrum Tube, Helium Gas	Each 3.50
87220	Spectrum Tube, Neon Gas	Each 3.50
87225	Spectrum Tube, Carbonic Acid Gas	Each 2.25
87230	Spectrum Tube, Chlorine Gas	Each 2.50
87235	Spectrum Tube, Hydrogen Gas	Each 3.75
87240	Spectrum Tube, Nitrogen Gas	Each 3.50
87242	Spectrum Tube, Air.....	Each 2.25
87245	Spectrum Tube, Oxygen Gas	Each 2.10
87255	Spectrum Tube, Iodine Vapor	Each 3.00
87260	Spectrum Tube, Mercury Vapor	Each 2.25
87265	Spectrum Tube, Water Vapor	Each 2.25

Spectrum Tube Discounts: 10% in lots of 6 of one kind



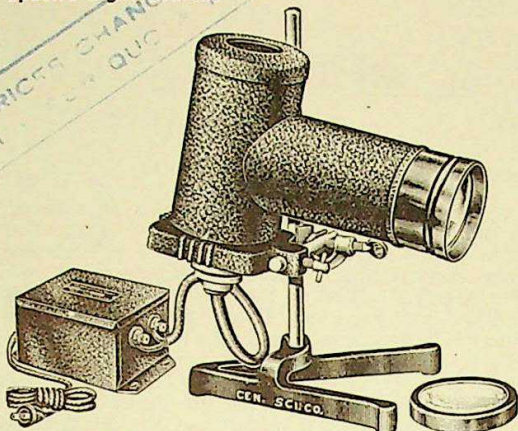
71377-84485

71377 LAMP, Argon Mixed Gas Glow, Medium Screw Base, 2 Watts, for normal use on 115 volts A.C. or D.C. for producing radiation in the near ultraviolet range which is most effective in producing fluorescence. Although called an Argon Lamp, it contains mixed gases and gives a hybrid spectrum. Can be operated at a minimum of 50 volts below normal on A.C. and 10 volts below normal on D.C. When used on D.C., only one electrode glows but gives the same energy as do both electrodes on A.C. Each .50*

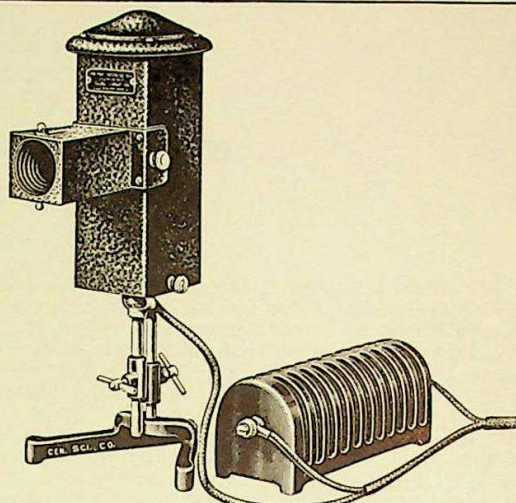
84485 LAMP, Neon Glow, Medium Screw Base, 2 Watts, for normal use on 115 volts A.C. or D.C. Can also be operated at a minimum of 50 volts below normal on A.C. and 10 volts below normal on D.C. When used on D.C., only one electrode glows but gives the same energy as do both electrodes on A.C. Each .50*

*Federal excise tax extra, if applicable.

LIGHT Spectra Light Sources



87268 shown with No. 85270 Lens



87271

- 87268 LIGHT SOURCE, High Pressure Mercury Arc**, for producing intense illumination, especially where the spectral characteristics of the mercury vapor arc are desired. The light is rich in ultraviolet radiations and when used with the filter holder and filter supplied with it, ultraviolet fluorescence effects may be demonstrated at distances as great as 30 to 40 feet from the lamp. The photoelectric effect may be demonstrated by using the light with a No. 71020 Zeleny Electroscopic. This lamp is an excellent light source for optical experiments. Either a parallel or a long converging beam of light may be secured by adjusting the condensing lens. A short, sharply-focused beam of light is secured by using a No. 85270 Auxiliary Lens over the condensing lens.

Consists of a No. 87269 High Pressure Mercury Arc Lamp mounted within a well-ventilated housing with adjustable condensing lens, adjustable support stand, and operating transformer. The lamp housing is of attractive design with baked, black wrinkle finish. It is attached to the substantial support stand by means of a nickel-plated rod that extends horizontally from the base of the lamp housing. The connection with the vertical rod of the support stand is by means of a right angle clamp. Adjustments for directing the light beam wherever desirable are easily made. The base of the housing is drilled and tapped to take a No. 72162 Threaded Rod to permit the use of the light source in the carriage of No. 85801 Demonstration Bench. The transformer operates from 115-volt, 60-cycle circuits. Complete with filter, filter holder, transformer, transformer leads and connecting cord with attachment plug, but **without** auxiliary lens or threaded rod.....**Each \$55.00***

5% discount in lots of 3

- 87269 Lamp Bulb, High Pressure Mercury Arc**, only, for replacement in No. 87268 Light Source. Consists of a cylindrical glass bulb, with special size screw base, within which a quartz bulb $1\frac{1}{2}$ inches long by $\frac{1}{8}$ inch in diameter is supported. The outer bulb is for protection only, as the high pressure arc is confined within the quartz bulb. The lamp must be operated within a housing for protection of the operator as the internal pressure will cause fragments of the bulb to fly when broken, in contrast with the usual evacuated lamp bulbs which collapse when broken. The arc stream is approximately 14 mm long. The initial light intensity is approximately 3000 lumens. The lamp operates at 130 volts and draws approximately 0.9 ampere. A special transformer, such as is supplied with No. 87268 Light Source, is required for operation from 115-volt, 60-cycle current sources.....**Each 11.50***

- 87271 LIGHT SOURCE, Quartz Mercury Vapor Arc, Cenco**, for experiments in optics and as a laboratory source of the visible and ultraviolet spectra of mercury. The quartz burner is of new design, and is mounted in a well-finished, light-tight ventilated housing, with a holder for filters. The housing is equipped with a $\frac{3}{8}$ inch (10 mm) rod for mounting in an optical bench carriage or on a table base and support, as illustrated. With the table mounting, the range of elevations of the center of the window is between 24 and 35 cm.

The filter holder may be removed from the housing and the mercury arc used unaltered. The selection of a suitable filter, as Nos. 87308 and 87310 Filters, permits selection of a single wave-length or spectral region. With No. 87310E Filter, for example, pure monochromatic green, i.e., the 5461 AU line, is transmitted.

The Cenco-Mercury Arc Lamp for laboratory use and demonstrations represents a great amount of development work, which has produced a highly reliable instrument. For demonstration purposes, for example, it is virtually a line source of light which, when viewed through diffraction slits and gratings, gives qualitative spectra and diffraction patterns. Projected through a prism of sufficient aperture, in a darkened room, the bright-line spectrum of mercury may be shown.

Intended for use on 115-volt D.C. only. Complete with table stand, housing, fixed resistor, and connecting rod**Each 92.50**

5% discount in lots of 3

- 87276 Quartz Burner, Mercury Arc**, only, for replacement in No. 87271 Light Source.....**Each 55.00**

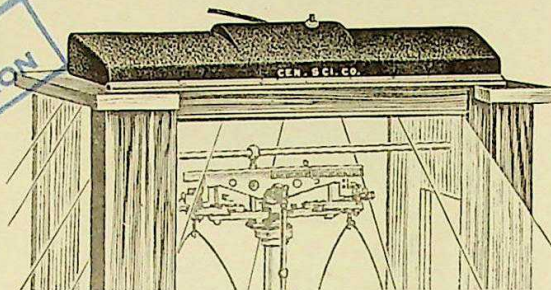
5% discount in lots of 3

Ultraviolet Filter: See No. 66164B, page 747.

*Federal excise tax extra, if applicable.

LIGHT
Spectra Light Sources

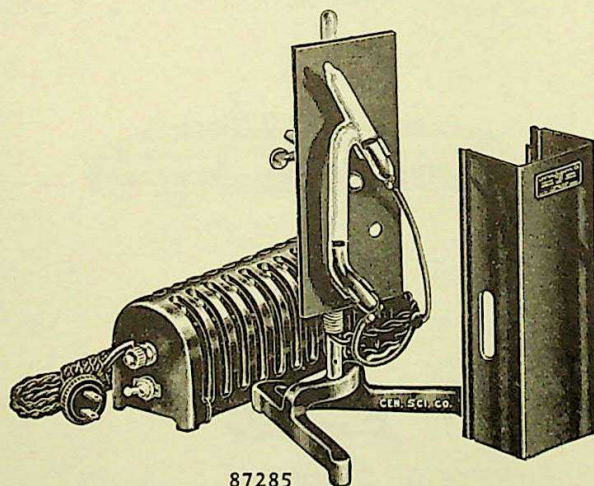
PRICES CHANGED
WRITE FOR QUOTATION



2085

- 87281 Tubular Lamp, Fluorescent Mercury Glow, Daylight**, for replacement in Nos. 2085, 87130 and 87293 Fluorescent Illuminators. Made with a tubular glass shell coated on the inside with fluorescent material that emits a brilliant daylight glow under stimulus of short-wave radiation from the mercury vapor arc within the tube. Current connections are made between the double terminals at each end of the tube, which fit into the terminal clips of the lamp fixture. Cannot be operated directly from 115-volt, 60-cycle current. Must be used in the receptacles and ballasts provided in fluorescent lamp fixtures of this current rating. Length, 18 inches. Power consumption, 15 watts.....**Each \$0.62***

- 2085 BALANCE ILLUMINATOR, White Fluorescent Mercury Glow**, for flooding the interior of an analytical balance with illumination that is free from sharp shadows or annoying glare. The 18-inch, tubular fluorescent lamp is housed in a white-enameled metal reflector with exterior finish of black wrinkle enamel. The housing is so designed that the lamp may be laid flush upon a glass balance case or other device to illuminate the space below. When laid on a table top with the lamp directed upward, the fixture may be used as a calorimeter, microscope or refractometer illuminator, or for titrations. No clamp is provided. Current demand for the lamp is only 15 watts, and the amount of heat produced is so small that it has no effect on sensitive instruments such as analytical balances. The illuminator is turned on and off by a single control button on top of the case; the necessary ballast is provided within the housing to permit operation on 115-volt, 60-cycle A.C. For replacement bulb, see No. 87281. Dimensions, over-all: length, 20 inches; width, 5 inches; height, 1 $\frac{3}{8}$ inches. Complete with 5-foot rubber-covered cord and plug.....**Each 8.00**



87285

- 87285 LIGHT SOURCE, Mercury Vapor Lamp, Cenco, B-W Type**, (Patent No. 1,987,754) for laboratory and experimental purposes. Designed by Drs. Balinkin and Wells of the University of Cincinnati. Made of "Pyrex" brand glass tubing, with specially designed tungsten electrodes. The lamp is so designed that it is started by tilting, with the voltage so adjusted that a current in excess of normal operating current flows for a minute or two, to bring the vapor up to operating temperature. The resistor in series with which the lamp must be operated on 115 volts D.C. has a starting switch at one end of its housing which is held in the "on" position for a minute or two.

The lamp is fastened by means of two spring clips to a small rectangular panel of transite. To this panel is affixed a $\frac{3}{8}$ inch (10 mm) rod which extends horizontally for attachment to the vertical rod of a Harrington support stand by means of a right angle clamp. A sheet metal housing, finished in black wrinkle enamel, is provided to slip over the rectangular panel when the glass lamp is in place. A small slit in the side of the housing permits directing the light to the subject. The Cenco B-W Mercury Vapor Light Source is characterized by great steadiness. Once started, it continues in operation until the current is shut off. Several of these lamps have been in continuous operation in excess of 3000 hours. With support stand, resistor, connecting cord, and attachment plug.....**Each 36.00**

10% discount in lots of 6

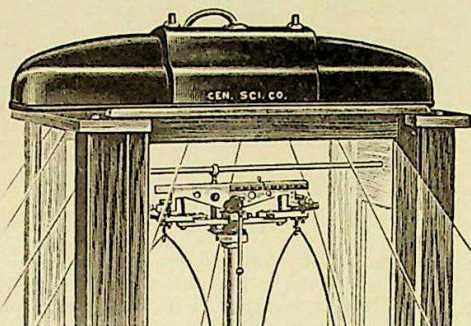
- 87286 Mercury Vapor Lamp Burner, Cenco, B-W Type**, (Patent No. 1,987,754) for replacement in No. 87285 Light Source**Each 13.50**

10% discount in lots of 6

*Federal excise tax extra, if applicable.

LIGHT

Spectra Light Sources

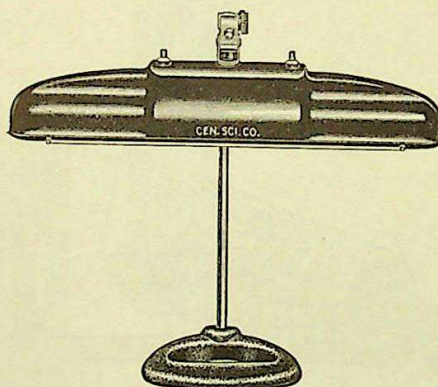


87293

- 87293 BALANCE ILLUMINATOR, Daylight Fluorescent**, for providing glareless, cool illumination for analytical balances. The smooth, corrosion-resistant bakelite housing may be on top of the balance case or suspended wherever artificial light of daylight quality may be needed. The tubular lamp emits light from a fluorescent coating which converts the radiation of a mercury arc into visible radiation having a continuous spectrum with a mercury spectrum superimposed. This produces a white light which is easy on the eyes, approaching daylight in quality, economical and cool in use.

Complete with manually operated switch with dual on-off buttons which eliminate the warm-up period, and 15 watt fluorescent daylight bulb. For replacement bulb, see No. 87281. For operation on 115-volt, 60-cycle A.C. Each \$14.25

10% discount in lots of 6



87294

- 87294 FLUORESCENT ILLUMINATOR, Daylight**, similar to No. 87293 Illuminator, but with the addition of an adjustable support stand. The chromium-plated stand with wrinkle finish base permits the lamp to be used horizontally, vertically, or at an angle. The height or position of the lamp is adjustable. Complete with lamp, support stand and 15 watt fluorescent daylight bulb, for operation on 115-volt, 60-cycle A.C. Each 20.65

10% discount in lots of 6

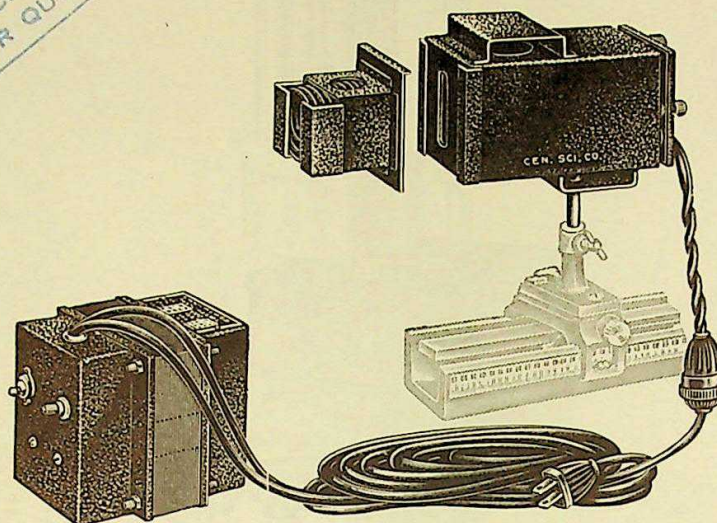
- 87298 LIGHT SOURCE, Cenco Quartz Mercury Arc, A.C. Operation**, for generating radiations of wavelengths from the blue and green mercury lines into the ultraviolet region as far as 2260 Angstrom units. The ultraviolet intensity of radiations of 3130 Angstrom units and shorter, measured at a 20-inch distance, is over 250 microwatts per square centimeter. It is especially suited for the illumination of optical apertures in spectroscopy and with a filter for fluorescence analysis.

The quartz burner is enclosed in a well-ventilated housing, equipped with a $\frac{3}{8}$ -inch diameter support rod of 10 cm length to permit use of the lamp on standard optical bench carriages or on No. 72202 Stand Tube Support. The front of the housing is enclosed, except for a $4\frac{1}{2}$ by 1 cm slot through which the radiation is directed from the burner by adjustment of the burner mount at the rear of the housing by means of 4 knurled adjustment nuts. Provision is also made on the front of the housing for attachment of No. 87299 Filter Holder.

(Continued on next page)

LIGHT
Spectra Light Sources

PRICES CHANGED
WRITE FOR QUOTATION

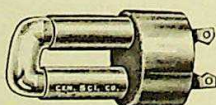


87298-87299

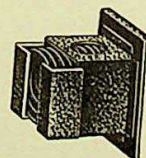
87298 LIGHT SOURCE, Cenco Quartz Mercury Arc, A.C. Operation, (continued from preceding page).

The quartz burner consists of a high pressure electronic discharge mercury arc in a fused quartz envelope. The envelope is C-shaped and is of such dimensions that it has an active arc length of about 40 mm. It is mounted on a base with two contact prongs which plug into the porcelain base of the burner mount. Proper current characteristics for operation of the burner are secured from a transformer supplied with the unit. The burner is attached to this control unit by a rubber-covered cord. An on-and-off switch controls the 115-volt, 60-cycle line current while a "tickler" switch assists in starting the arc when the potential is first applied to the burner. Usually the burner will light without the use of the "tickler" switch. About three minutes are required after starting the lamp for electrical stabilization and full ultraviolet intensity. The burner draws 1.2 amperes at 90 volts after stabilization. The control unit is rated at 125 watts. After the burner is lighted, it should remain in operation for at least 10 minutes before turning off. Frequent lighting is harmful and shortens its useful life. The control unit is provided with a 6-foot rubber-covered connecting cord with attachment plug for connection to a 115-volt, 60-cycle alternating current outlet. The control unit will be damaged if operation is attempted from direct current. Complete with quartz burner and control unit, but **without** filter holder or filters. **Each \$92.00**

5% discount in lots of 3



87298A



87299

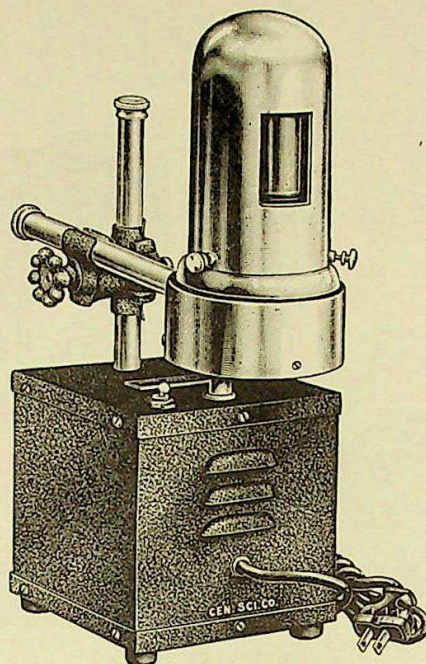
87298A Mercury Arc Burner, only, for replacement in No. 87298 Light Source. The envelope, of solarizing-resistant fused quartz, will withstand the high temperature and powerful molecular mercury bombardment of the high-pressure arc. Must be operated from the control unit of No. 87298 Light Source on 115-volt, 60-cycle alternating current only.

The quartz tube of the burner must not be handled by the fingers, as the surface can be etched by the oily finger marks. Before lighting the tube, it should always be wiped off with a piece of clean cotton moistened with grain alcohol. **Without control unit.....Each 35.00**

87299 Filter Holder, for attachment to the housing of No. 87298 Light Source to permit use of filters up to 5 cm square for transmitting portions of the radiant energy spectrum emitted by the quartz burner. Without filters.....Each 6.50

10% discount in lots of 6

LIGHT
Sodium Arc Lamp



87300

- 87300 SODIUM ARC LAMP**, a compact, portable, convenient source of sodium light of high intensity. It finds extensive laboratory use in polarimetry, interferometry, refractometry, spectrometry and other optical work. The lamp is particularly valuable where chemical constituents or concentrations are measured as functions of monochromatic light absorption. It is useful for detection of fine surface cracks and for inspection of surfaces by the interference patterns formed with test plates. Its light may be used for calibration of spectrometers, spectroscopes and spectrographs.

The radiation source is of ample area, giving constant intensity and high brilliance. The lamp may be operated for long periods with unvarying output. No adjustment or maintenance is required and there are no fumes and very little heat. The Sodium Arc Lamp consists of two units, a lamp housing and a base. The base contains a transformer and a resistor. A rod extending from the base provides support for the lamp. The lamp housing encloses a vacuum flask mantle which fits over the lamp to retain the heat necessary for proper operating temperature and stable light output. The lamp window is a $1\frac{1}{2} \times 2$ inch rectangular opening. The bulb is equipped with a 4-prong, radio type base for easy replacement. It is 5 inches long over-all, including base pins, and $1\frac{3}{4}$ inches in diameter. A 4-conductor cable from the lamp receptacle in the bottom of the housing connects the lamp to the base. Lamp housing is polished aluminum; base is finished in black wrinkle enamel.

With the lamp fully warmed up (after 20 to 40 minutes), the Sodium Arc Bulb produces about 650 lumens. This is largely concentrated in the 5889-5895 lines of the spectrum. Brightness of the center square in the window area, about 3×3 cm, averages 7.5 candles per sq. cm, or a total of about 85 candle power. If the electrodes are shielded to utilize the area 2×3 cm between them, the brightness is 9 candles per sq. cm. This is over thirty times the brightness of the average sodium flame. Use of a filter is recommended to eliminate the 2 per cent of radiation in unwanted lines. A bichromate filter, if used, may be adjusted to as high an absorption as conditions require. Wratten filters, Nos. 87310F and G, may be used in combination. No provision is made for holding filters on the lamp housing. Gelatin filters should be mounted about 6 inches away from the lamp to avoid overheating.

For operation on 115 volt, 60 cycle A.C.; power demand, 65 watts. Complete with 6-foot connecting cord and plug, but **without filters**. **Each \$85.00***

- 87302 Sodium Arc Bulb**, only, for replacement in No. 87300 Lamp. Rated average useful life, about 500 hours. **Each 12.00***

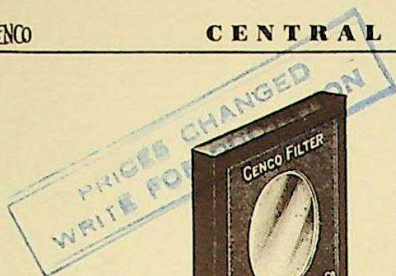
*Federal excise tax extra, if applicable.

- 87305 LIGHT FILTER, Infrared or Heat Absorbing**, for insertion in optical systems between the source of illumination and materials under illumination to protect them from heat radiation. May be used in optical bench experiments in No. 72288 Lens Clamp. Diameter, 7.5 cm; thickness, 3 mm **Each .80**

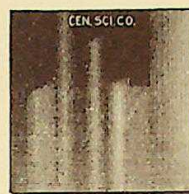
10% discount in lots of 12

- 87307 LIGHT FILTER, Infrared or Heat Transmitting**, for use on illuminators for operating photoelectric relays by invisible light. Consists of a square of special polished glass, which is opaque to visible radiation but transmits most of the infrared between 1μ and 3μ . Dimensions: length, 5 cm; width, 5 cm; thickness, 3.5 mm. **Each 4.20**

10% discount in lots of 6

LIGHT
Light Filters

87308-309-312



87318

87308 LIGHT FILTERS, Glass, Narrow Transmission Band, Cenco, for transmission of a narrow band of light, the spectral range of which is approximately 60 to 80 $m\mu$ in width. The wave-length at which maximum transmission occurs for each filter is indicated below. Filters Nos. 335B and 610B are "cut-off" filters; the former absorbs light of wave-lengths greater than 410 $m\mu$, the latter of wave-lengths less than 610 $m\mu$.

These filters are more dense than No. 87309 Light Filters, consequently the spectral region isolated is somewhat narrower. Although No. 87309 Light Filters are generally recommended for use with the "Photometer," No. 87308 Filters may be used in "Photometers," serial Nos. 352 and above, if the fixed diaphragm is removed.

Each filter is mounted in a mask, $2\frac{1}{4}$ by $2\frac{1}{2}$ inches, and properly identified. The filter aperture is $1\frac{1}{16}$ inches in diameter.

Type No.	1	2	3	4		
Central Max., $m\mu$	410 cut-off	390	435	465		
Each	\$6.65	11.60	9.00	8.15		
Type No.	5	6	7	8	10	11
Central Max., $m\mu$	490	515	550	575	610	610 cut-off
Each	9.00	11.15	11.15	7.85	7.85	4.05

10% discount in lots of 6

87309 LIGHT FILTERS, Glass, "Photometer", Cenco, for use with Nos. 29300, 29310, and 41000 "Photometers" to transmit wavelengths in various portions of the spectrum used in analytical work. Each filter is mounted in a mask, $2\frac{1}{4}$ by $2\frac{1}{2}$ inches, and properly identified. The filter aperture is $1\frac{1}{8}$ inches in diameter.

No.	A	B	C	D
Central Max., $m\mu$	410	525	610	645
Each	4.05	6.80	4.50	8.15

10% discount in lots of 6

87310 LIGHT FILTERS, Mercury and Sodium Arc Monochromats, Wratten, for use with No. 87271 Mercury Arc and No. 87300 Sodium Arc for selective transmission of certain narrow regions of their spectra. Consist of genuine Wratten color films cemented in 2 inch squares of white optical glass suitable for use in the path of a dispersed beam of light. Nos. A, B, and C are suitable for ordinary purposes with the mercury arc. Nos. D and E are special filters for more precise work. No. D transmits 0.5 per cent of the yellow lines and 72 per cent of 546 $m\mu$. No. E transmits no yellow and 50 per cent of 546 $m\mu$. Nos. F and G Filters in series transmit the sodium doublet.

No.	A	C	D	E	F	G
Transmits, line	Yellow	Blue & Violet	Green	Green	Blue Green	Red
Each	3.15	3.15	19.50	28.75	3.15	3.15

87312 LIGHT FILTERS, Heat Absorbing, Glass, "Photometer," Cenco, for absorbing heat radiation from Nos. 29300, 29310, and 41000 "Photometers." No. 750PL Heat Absorber is intended for use with band filters, and No. 750PH for use in special types of work requiring no filters. Mounted in masks, $2\frac{1}{4}$ by $2\frac{1}{2}$ inches, with filter aperture $1\frac{1}{8}$ inches in diameter.

Size No.	A	B
No.	750PH	750PL
Relative transmission	High	Low
Each	1.50	5.75

10% discount in lots of 6

87318 LIGHT FILTERS, Cenco, for use wherever colored light is needed, such as in demonstrations with No. 85580 Lumirod, or wherever restricted portions of the visible spectrum are to be used. By combining two or more of the filters, their normal transmission ranges are further limited to narrower bands of wavelengths.

The set consists of six numbered glass filters in a hinged-lid, leatherette-covered compartment case with nickel-plated snap-catch. The approximate transmission ranges are: No. 1 from 7000 to 6000 AU; No. 2 from 7000 to 5500 AU; No. 3 from 7000 to 5300 AU; No. 4 from 6300 to 4500 AU; No. 5 from 6500 to 4000 AU; and No. 6 from 5900 to 4000 AU. A printed card in the lid of the case shows the approximate transmission bands of the filters. Dimensions of filters: length, 5 cm; width, 5 cm; thickness, 2.5 mm. Complete set of 6 filters with case.

Per set 6.50

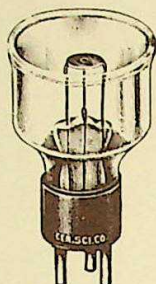
10% discount in lots of 6

LIGHT

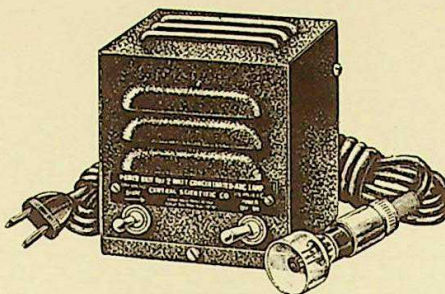
Concentrated-Arc Lamps



87320



87324



87330



87336

- 87320 CONCENTRATED-ARC LAMP, 2 Watt, A2**, for producing a brilliant white light which is ten times brighter than that of a tungsten filament. The light source of 0.003 inch diameter almost approximates a true point of light. The arc, produced on a thin film of zirconium by electrodes enclosed in an argon-filled bulb, has high stability and resolving power. The parallel rays of great intensity are valuable in demonstrating optical phenomena and testing lenses. This intense light is used in microscope illumination, photographic enlarging and projection, and opaque projection of small objects. The bulb burns in any position and has an average life of 175 hours. The maximum light intensity is 62,000 candles per square inch; candlepower, 0.32 candles. The effects of striation and irregularities in the glass are reduced by a thin-walled bubble in the end of the bulb. The light is projected parallel to the axis of the bulb. Operating voltage is 37 volts at 0.055 amps. For use with 2 watt power supply No. 87330. The lamp fits miniature 3-pin sockets. Diameter, $\frac{3}{4}$ inch; height, over-all, 2 inches. Each \$7.00*

10% discount in lots of 6

- 87324 CONCENTRATED-ARC LAMP, 2 Watt, Flat Lens End View, C2**, similar to No. 87320 Lamp, but with flat, ground and polished window or flat lens sealed into the end of the bulb where maximum clarity is desired, as for optical testing. For use with 2 watt power supply No. 87330. Diameter of bulb, $1\frac{1}{8}$ inches. Each 14.50*

10% discount in lots of 6

- 87330 POWER SUPPLY UNIT, 2 Watt**, for use with lamp Nos. 87320 and 87324 to provide proper starting and operating voltages. Power demand, 42 watts. Units for use on other voltages and frequencies may be purchased on special order. Complete with connecting cords, plug and socket for the lamp.

No.	A	B
For volts, 50/60 cycles A.C.	115	230
Each	27.50	30.00

10% discount in lots of 6

- 87331 CONCENTRATED-ARC LAMP, 10 Watt, End View, A10**, similar to No. 87320 Lamp, but for use with 10 watt power supply No. 87335. The maximum light intensity is 35,400 candles per square inch; candlepower, 0.32 candles. The lamp has a light source 0.016 inches in diameter and maximum temperature of 225° F. Average life is 700 hours. Operating voltage is 21 volts at 0.5 amps. The lamp fits small 8-pin radio sockets. Diameter, 1 inch; height, over-all, $3\frac{1}{2}$ inches. Each 10.00*

10% discount in lots of 6

- 87332 CONCENTRATED-ARC LAMP, 10 Watt, Side View, K10**, similar to No. 87331 Lamp, but with light source arranged to emit from the side of the lamp, perpendicular to its axis. For use with power supply No. 87335. Each 9.75

10% discount in lots of 6

- 87335 POWER SUPPLY UNIT, 10 Watt**, for use with Lamp Nos. 87331 and 87332 to provide proper starting and operating voltages. Power demand, 40 watts. For use on 115 volt, 50/60 cycle A.C. Units for use on other voltages and frequencies may be purchased on special order. Complete with connecting cords, plug and socket for the lamp. Each 95.00

- 87336 CONCENTRATED-ARC LAMP, 25 Watt, End View, A25**, similar to No. 87320 Lamp, but for use with 25 watt power supply No. 87340. Adequate ventilation must be provided to prevent overheating. The maximum light intensity is 26,000 candles per square inch; candlepower, 8.7 candles. Diameter of light source is 0.029 inch; maximum temperature, 355° F. Average life is 800 hours. Operating voltage is 20 volts at 1.25 amps. The lamp fits small 8-pin radio sockets. Diameter, $1\frac{1}{4}$ inches; height, over-all, $3\frac{1}{2}$ inches. Each 14.00*

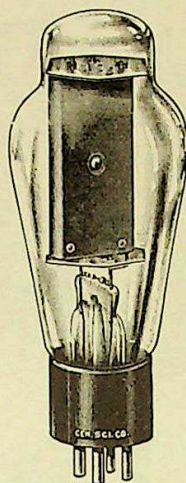
10% discount in lots of 6

- 87337 CONCENTRATED-ARC LAMP, 25 Watt, Side View, K25**, similar to No. 87336 Lamp, but with light source arranged to emit from the side of the lamp, perpendicular to its axis. For use with power supply No. 87340. Each 13.50

10% discount in lots of 6

*Federal excise tax extra, if applicable.

PRICES CHANGED
WRITE FOR QUOTATION



87341

LIGHT
Concentrated-Arc Lamp
Color Mixing

87340 POWER SUPPLY UNIT, 25 Watt, for use with Lamps Nos. 87336 and 87337 to provide proper starting and operating voltages. Power demand, 65 watts. For use on 115 volt, 50/60 cycle A.C. Units for use on other voltages and frequencies may be purchased on special order. Complete with connecting cords, plug and socket for the lamp.....**Each \$110.00**

87341 CONCENTRATED-ARC LAMP, 100 Watt, Side View, K100, similar to No. 87337 Lamp, but for use with 100 watt power supply No. 87345. Adequate ventilation must be provided to prevent overheating. This lamp is recommended for use in photographic enlarging and projection. The maximum light intensity is 33,600 candles per square inch; candlepower, 77 candles. Diameter of the light source is 0.059 inch. Average life, 1000 hours. Operating voltage is 15.4 volts at 6.25 amps. The lamp fits medium 4-pin radio sockets. Diameter, 2 inches; height, over-all, 5 inches.....**Each 19.75***

10% discount in lots of 6

*Federal excise tax extra, if applicable.

87345 POWER SUPPLY UNIT, 100 Watt, for use with Lamp No. 87341 to provide proper starting and operating voltages. Power demand, 200 watts. For use on 115 volt, 50/60 cycle A.C. Units for use on other voltages and frequencies may be purchased on special order. Complete with connecting cords, plug and socket for the lamp.....**Each 140.00**

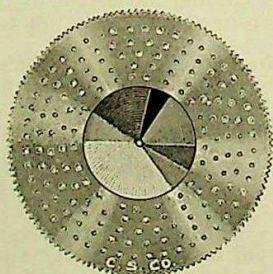
87360 GLASS PLATE SET, Colored, consisting of a complete set of No. 87362 Glass Plates. These are ordinary colored glass plates for imparting color to a light beam and are not intended for use as filters. For better grades of filters, see Nos. 87308 and 87318 Filters. Size, 10 cm square. Set of seven.....**Per set 1.15**

10% discount in lots of 12

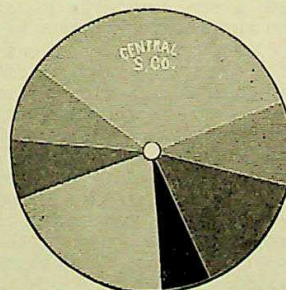
87362 Glass Plates, Colored, only, of No. 87360 Set, for replacement.

No.	A	B	C	D	E	F	G
Color	Violet	Indigo	Blue	Green	Yellow	Orange	Red
Each	.30	.16	.12	.14	.12	.12	.20

10% discount in lots of 50



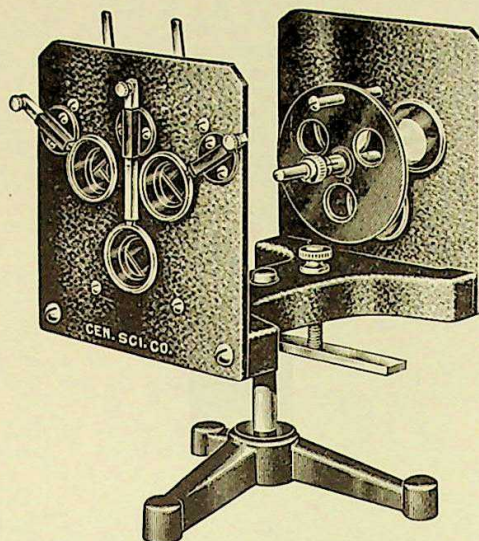
74585



74600

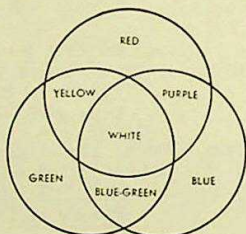
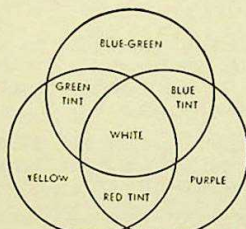
74585 ACOUSTIC AND COLOR DISK, Combined, for demonstrating a siren disk, Savart's Wheel and Newton's Color Disk. Consists of a toothed-edge metal disk 25 cm in diameter, with primary colors in the center in the proper proportion to produce white when rotated rapidly. Finished in white metal plate.**Each 5.85**

74600 COLOR DISK, Newton, Metal, for demonstrating that the primary colors in the proper ratio will produce white when rotated rapidly. Consists of a zinc disk, with perforation for No. 74425 Spindle, upon which colored sectors are cemented. Diameter, 20 cm. Without spindle.....**Each 3.60**

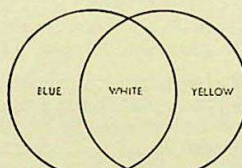
LIGHT
Color Mixing


87380

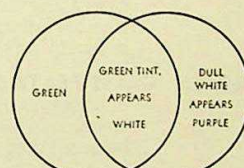
87380 VON NARDROFF COLOR APPARATUS, designed from suggestions by Dr. Von Nardroff, principal of the Stuyvesant High School, New York City. Provides a convenient and satisfactory apparatus for the study of color phenomena where only one projection lantern is available. Mounted so that it is well adapted for use with No. 85261 Cenco Arc Illuminator or No. 85262 Incandescent Illuminator. Briefly, the apparatus is an attachment that converts an ordinary projection lantern into a triple lantern in which each of the three beams of light has independent intensity and direction. The general form and design is clearly indicated by the illustration above, showing two positions.

Maxwell's Primary
Hues

False Primary Hues



Complementary Hues

Contrast
Effects**Experiments**

A Study of Primaries and Secondaries. The red, green, and blue glasses provided with the apparatus are placed in the glass holders. By a movement of the lens arm these circles of red, green, and blue may be overlapped either in whole or in part as desired and, by means of the diaphragms, the intensity of strength of each color readily regulated. The effect of mixing the primaries in any desired portion, in pairs or in triples, is readily seen.

False Primaries. The glasses selected should be the purple, yellow and blue-green, and by proper manipulation of the diaphragms all possible hues, as well as white, may be obtained.

Complementary Hues are easily illustrated by carefully choosing the pairs of colored glasses to obtain the desired results.

"The Green Question" is solved by superimposing the yellow and blue glasses in the single slide holder of the apparatus and again

inserting the same glasses in separate slide holders, adding the beams by overlapping on the screen, noting that a pure white light is obtained.

Contrasting effects are strikingly illustrated when a saturated color, such as green, is projected and the white disc, arranged to overlap partially, is turned on; the overlap, which is really a tint, appears nearly white, while the remaining white appears strongly colored by the complementary hue. If the order of projection is reversed, the sudden appearance of the white is very impressive.

A Study of Tints is easily made by adding to the white beam a colored beam adjusted for intensity.

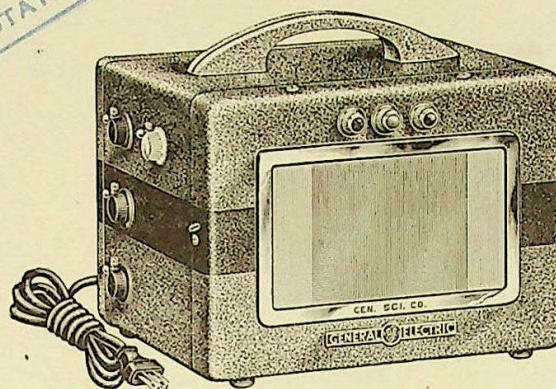
Other Experiments. Many additional experiments will suggest themselves to the user after he has become familiar with the apparatus and commences to learn some of its possibilities.

Complete, with six color filters and directions for use.....**Each \$60.00**

5% discount in lots of 3

LIGHT
Color Mixing

PRICES CHANGED
WRITE FOR QUOTATION



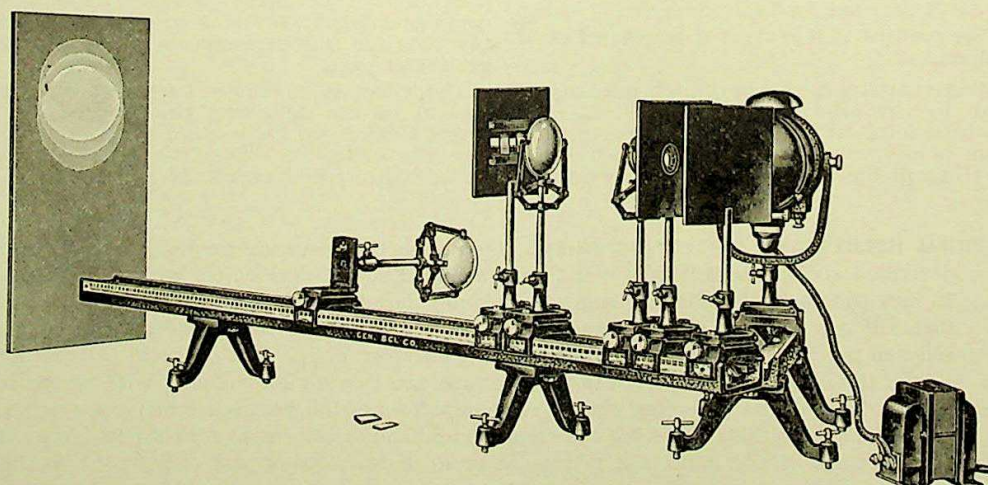
87385

87385 COLOR MIXER, G-E COLORSCOPE, for clear and vivid demonstration of the additive method of color mixture. With this unit the primary colors (red, green, and blue) can be combined to show all the shades of the visible light spectrum. In colorimetric analysis, the colorscope can be used to demonstrate the theory of light absorption and transmission in chemical solution. This device will prove a valuable aid to lecturers and teachers in the fields of physics and art.

The colorscope is provided with light sources which produce each of the three primary colors used in mixing colored lights: red, green and blue. The intensity of each lamp can be controlled individually by means of a separate switch and variable resistor. Relative intensity of each of the three lamps is indicated by the brightness of the three small lights mounted above the viewing screen.

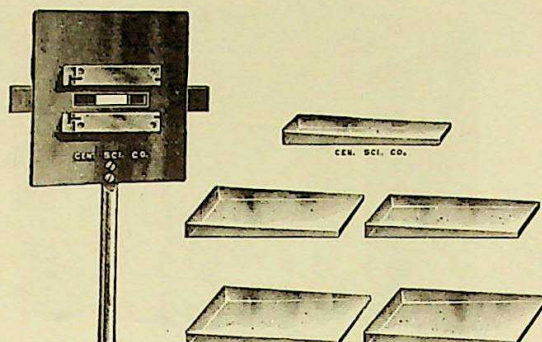
The viewing screen is divided into three sections. The two smaller ones on either side are illuminated with artificially produced daylight to provide the standard comparison color. The center and larger section of the screen is illuminated by the light coming from the three primary-colored lamps. Dimensions: height, 8¼ inches; width, 12½ inches; depth, 9½ inches. Net weight, 10 pounds. For operation on 115 volts A.C. or D.C. Complete with cord and plug and one each 75-watt, red, green and blue incandescent lamps. **Each \$84.00**

5% discount in lots of 3



Color mixing with No. 87400 Prism Holder and Deflecting Prisms on No. 85801 Bench, employing accessories as described on the following page.

LIGHT
Color Mixing



87400

SPECTRUM PROJECTOR AND SPECTRAL COLOR MIXER, CENCO

Exceedingly satisfactory results in demonstrations on color mixing and spectrum projection may be obtained from the following accessories on Nos. 85801 and 85810 Optical Benches. All the parts are standard; the supports have 10 mm rods to fit the regular optical bench carriage.

- 1 No. 85801 Optical Bench
- 1 No. 85810 Auxiliary Bench
- 1 No. 86605 Illuminator
- 1 No. 86607 Light Shield
- 3 No. 72288 Lens Holders
- 2 No. 85645-8 Double Convex Lenses
- 1 No. 85705 Achromatic Lens
- 1 No. 86005 Ground Glass Screen*
- 1 No. 86105 Mounted Iris Diaphragm
- 1 No. 86110 Grating Holder
- 1 No. 86845A Plane Reflection Grating
- 1 No. 87400 Prism Holder with 5 Deflecting Prisms
- 3 No. 85802 Carriages
- 1 No. 85804 Carriage for Light Source

*May be omitted if it is desired to project on a wall screen.

With these parts, a spectrum of high intensity is produced by the diffraction grating. This is brought to a focus at the horizontal aperture of the prism holder, and an enlarged image is produced by one of the double convex lenses on the

screen. At the same time, the iris diaphragm is imaged on the screen by the second double convex lens when the first is tilted out of the light beam. Thus, by tilting this lens into the beam, a spectrum is projected; by tilting it out, the iris diaphragm is projected in white light.

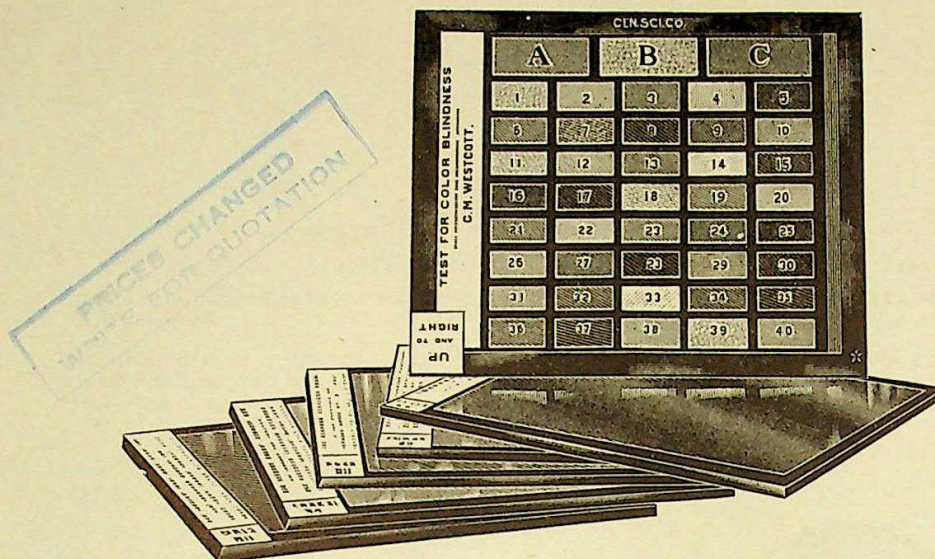
If part of the spectrum is now cut off at the aperture of the prism holder, the image of the diaphragm is colored—i.e., it shows the resultant of those colors that are not cut off. Thus, by moving one or the other or both slides, to cut off part of the spectrum, the color of the round image changes. For any particular color, the composition may be analyzed by tilting the lens up, so that it projects that part of the spectrum which is combined to make the color.

A still more effective demonstration is to insert one of the deflecting prisms in the spectrum at the prism holder. Tilting the lens down then produces two overlapping spots. Where they overlap, the light is white, because the whole spectrum is there recombined. In the non-overlapping portions, the color of one spot is complementary to the other. Thus every possible combination of complementary colors may be shown. The assembly used for this demonstration is shown on the preceding page.

The effect is strikingly beautiful, especially if several of the deflecting prisms are used. The Prism Holder and Deflecting Prisms are listed below. The other items listed are described in detail under their respective numbers.

87400 PRISM HOLDER AND DEFLECTING PRISMS, for use in the spectrum projector and color mixer, described above. Consists of a metal light shield, finished dull black, with a horizontal slot 10 mm wide and of sufficient length to accommodate the spectrum. On one side of the aperture are two grooves, with spring retainers, for the opaque metal slides, with which any selected portions of the spectrum may be cut off from either end, or both. On the opposite side of the light shield, adjacent to the aperture, are two similar grooves, with spring retainers, for holding the deflecting prisms vertically. Two of the prisms are of proper width to fit horizontally into the grooves for the metal slides. The arrangement makes possible numerous combinations of the deflecting prisms, to produce deviation of part of the light, so that two or more overlapping circles of colored light may be projected. Complete with two metal slides and five deflecting prisms. (See illustration on preceding page.).....Each \$15.00

10% discount in lots of 6

LIGHT
Color Slides

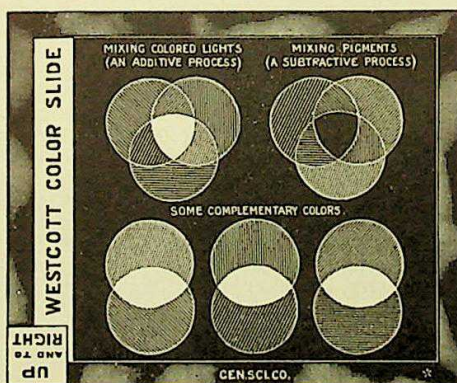
87410

87410 COLOR BLINDNESS SLIDES, Westcott's, for testing color blindness. The well known Holmgren tests for color blindness, in which samples of colored yarns are used, are satisfactory for individual tests, but do not lend themselves well for group testing or demonstration.

The Westcott Slides are designed to overcome the objections to the Holmgren yarn tests. In physics courses they are especially valuable as an aid in the teaching of color vision.

Six slides comprise the complete set, as follows: one test slide with three test colors and forty numbered samples; three screens of uniform color, which, when superimposed on the test slide, illustrate the appearance of the test slide to the green-blind, red-blind and violet-blind eye, respectively; one slide showing the structure of the retina; and one to illustrate the Young-Helmholtz theory. With directions for use in a projection lantern....Per set \$12.00

10% discount in lots of 6



87412

87412 COLOR MIXING SLIDE, Westcott's, for showing by projection the effects of mixing colors and pigments. In the upper left corner are three overlapping disks of colored gelatin, representing the three primary colors of the Young-Helmholtz theory. The overlapping sectors show the colors which would result from mixing colored lights on a white screen. The central sector, representing the mixture of all three colors, is clear (white). This demonstrates effectively the additive effect of actual color mixing.

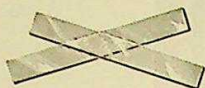
The upper right corner shows the subtractive effect of mixing pigments. The central sector in this instance is black, representing total absence of color due to combined absorption.

The combinations on the lower half of the slide show three pairs of complementary colors (not pigments). The overlapping field is in each case clear, showing that the effect of adding the members of each pair is to produce white light.

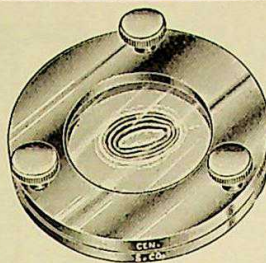
This slide is a valuable aid for every teacher of elementary physics who feels the need for additional lecture material with which to make clear this difficult subject.

Complete with precautionary directions for use in a projection lantern.....Each 6.25

10% discount in lots of 6

LIGHT
Interference


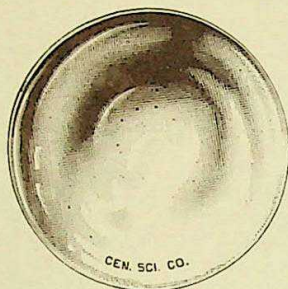
87455



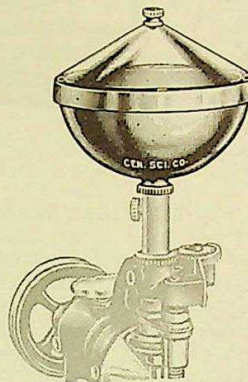
87460

87455 INTERFERENCE PLATES. Two pieces of plate glass about 9x2 cm for showing interference bands, as described in Millikan, Gale and Pyle's *Elements of Physics*.....Per pair \$0.22
 10% discount in lots of 36 pairs

87460 NEWTON'S RINGS APPARATUS, for showing interference of light. Consists of a pair of double convex lenses, 3.8 cm in diameter, mounted in brass frames, with three compression screws which also act as legs.....Each 3.65
 10% discount in lots of 6



87467



87470 shown in use

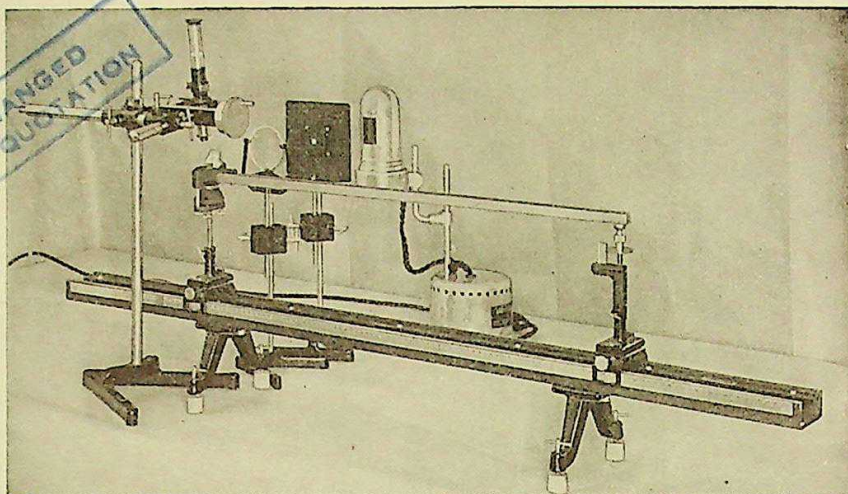
87467 OPTICAL FLAT, "Pyrex" Brand Glass, for use in checking gage blocks for parallelism of working surfaces and micrometers for parallelism of anvils, scale accuracy, zero-point settings, etc.; in checking zero readings on spherometers; and for similar tests. Made from a "Pyrex" brand glass disk 3 inches in diameter with a minimum thickness of $\frac{3}{8}$ inch. Both surfaces are polished, but one is ground flat to within a $\frac{1}{4}$ wavelength.....Each 40.00
 10% discount in lots of 3

87470 SOAP FILM INTERFERENCE APPARATUS, for demonstrating color phenomena and complete interference in thin films. The apparatus consists of a spun metal hemispherical shell, the edge of which is turned in, on the diametral plane, for receiving a soap film. The shell is finished black inside, and white nickel-plated outside. At the polar axis of the shell is a standard stud to fit the socket of No. 74350 Rotator. A close-fitting cover of transparent pyralin fits over the shell, to protect the film from air currents and keep the atmosphere about it saturated. No. 87475 Soap Solution is intended for use with the apparatus.

The experiment may be performed either by hand rotation of the apparatus, or by means of the motor. In the former case, the driving plate of the rotator is pushed back from the driven disk, and given a quarter turn to keep it out of engagement. The rotator spindle may then be turned by hand. Ordinarily, however, the motor is used. In this case, the spindle is clamped at about 10 degrees from the vertical. The film is formed by dipping the open side of the shell into a shallow dish containing the solution, and letting the excess drain back. The cover is then put in place, the shell clamped in the rotator socket, and rotation started at 5 to 7 revolutions per second.

The effect is very striking. When the surface of the film is examined by reflected white light, almost immediately after rotation begins, a series of colored Newton's rings is seen. These rings widen out, until they are very few in number. As rotation continues, the center of the film becomes straw colored, and eventually a tiny black spot appears. This gradually becomes larger; we have had the black spot as large as a silver dollar. This black spot is astonishing to the observer, because it appears as black as a sooted surface. If at this point rotation is stopped, and the film allowed to rest under gravity, the colors around the rim "float" downward; and by whirling the shell one way and then the other by hand, the black spot becomes disintegrated and the "particles" of black mixed with the reflecting portions of the film. After complete mixing in this manner, the rotator may again be driven regularly, when, surprisingly, the black "pieces" again become consolidated into a round spot at the center of the film. This Soap Film Apparatus provides almost unlimited mystifying entertainment with a scientific basis.....Each 14.50
 10% discount in lots of 6

87475 SOAP SOLUTION, specially prepared for use with No. 87470 Soap Film Interference Apparatus. This solution was developed to make particularly durable films. We have been able repeatedly to keep the film intact during 20 to 30 minutes of rotation. In 8-ounce bottles.....Each .45
 10% discount in lots of 24

LIGHT
Interference

No. 87480 Cenco-Longacre Interferometer with Accessories for Measuring Wave Length of Sodium Light

87480 INTERFEROMETER, Cenco-Longacre, for study of the interference of light and measurement of the wave length of light and index of refraction of transparent liquids. The interferometer was designed according to suggestions of Professor Andrew Longacre of Phillips Exeter Academy, as described in the *American Journal of Physics*, Vol. 8, No. 1, 38-40, February, 1940. The theory of operation and the manipulation of the instrument are such as to make the device useful in the light laboratory in the general course in college physics or in the optics laboratory connected with an advanced course in light.

The apparatus consists of two optically flat plates of glass, one of which is plane parallel and the other slightly wedge-shaped. The former is mounted in a fixed position; the other is securely fastened in a casting at one end of a long lever arm and so arranged that it may be placed close to but not touching the first plate on an axis parallel to the plates. At the opposite end of the lever arm is a micrometer screw by means of which the arm may be moved through a small measurable distance. This motion changes the angle between the inner reflecting surfaces of the glass plate. The light reflected from these surfaces produces parallel fringes on which measurements may be made. From the dimensions of the lever and the readings of the micrometer, the angular change between the surfaces may be computed. When a beam of monochromatic light is passed through the upper plate, the series of parallel fringes is observed. With decreasing angle between the plates, the fringes become wider; with increasing angle, narrower. By counting the fringes in a given distance from one setting of the plates and repeating when the setting has been changed by a known amount, it becomes possible to determine the wave length of the light used. Accurate measurement of the width of the fringes is made with a microscope on a micrometer slide.

The interferometer is designed for mounting in two optical bench carriages by means of $\frac{3}{8}$ inch rods. The lever on which the movable plate is mounted has three agate bearings arranged for "geometrical" mounting which fit two hardened steel points and the end of the micrometer screw, respectively. A total-reflecting prism directs the light downward to the plates. The micrometer microscope is mounted in a convenient position above the plates, with an objective distance of 85 to 90 mm and a magnifying power of about 22. To obtain sufficient working distance, the objective lens of the regular microscope, No. 72905, is replaced by No. 72926 Objective. As a source of monochromatic light, we recommend No. 87300 Sodium Arc, a sodium flame, or a small mercury vapor laboratory arc with a monochromatic filter. When a small quantity of liquid from a dropper pipette is made to fill the space between the two plates, which must be cleaned with great care, the width of the fringes is altered because of reduction in the velocity of light in the liquid. Measurement in the same manner as before gives data from which the index of refraction of the liquid may be computed from the wave length of light used. The accuracy of results of measurements with this apparatus is about one per cent. Interferometer only, without microscope, micrometer slide, lenses, light source or optical bench.....**Each \$50.00**

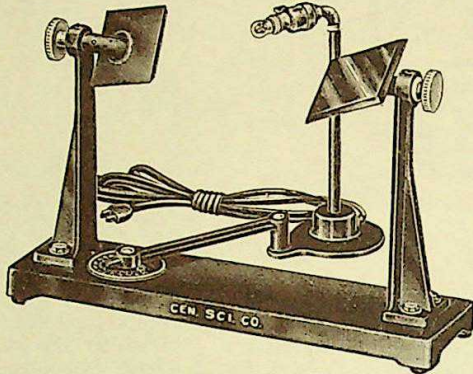
10% discount in lots of 3

For experiments employing this or similar apparatus, see S. E. P. L45b. See list of Manual References, page 1000.

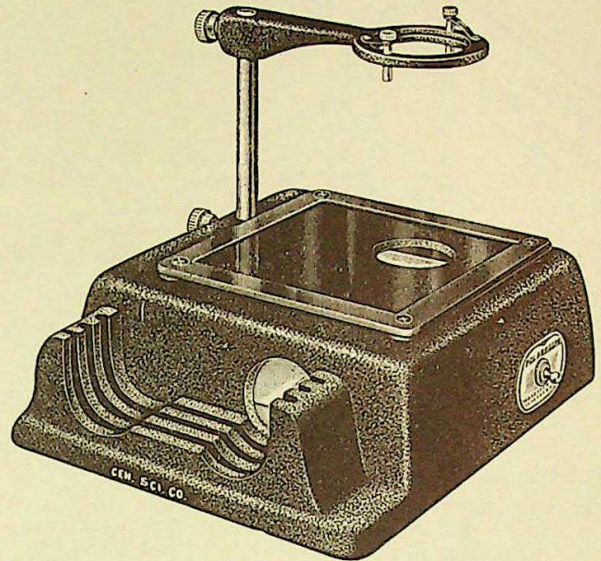
Complete list of Accessories Required for No. 87480 Interferometer:

1 No. 87801	Optical Bench	1 No. 72310D	Clamp
1 No. 72905	Microscope	1 No. 72340B	Clamp
1 No. 72926	Objective	1 No. 72000A	Base
1 No. 87300	Sodium Arc Lamp	1 No. 72162	Rod
1 No. 86105	Iris Diaphragm	1 No. 72261	Clamp
1 No. 72915	Micrometer Slide	1 No. 72288	Lens Holder
1 No. 72000C	Base	1 No. 85705	Lens
1 No. 72180	Support Rod	2 No. 85804	Carriages

LIGHT
Polarization



87506



87518

87506 POLARIZATION APPARATUS, Reflection Type, Neon Light Source, designed to meet the requirements of Experiment 105 in Minor's *Physical Measurements*. The apparatus is a modification of the Nörrenberg type, with the addition of a source of neon light. The light may be rotated about an axis perpendicular to the rotational axis of the two mirrors, and strikes one of the mirror surfaces at its approximate center. The mirrors, of black glass, are mounted at the proper polarizing angle relative to their common rotational axis. Supports for the mirrors are bolted to a substantial iron base with black, baked enamel finish. The light source is a No. 84490 Neon Glow Lamp, mounted in a candelabra socket on a swiveling arm. The arm rotates through 105°; the angle of incidence is measured by the protractor scale around the swivel. The apparatus may be used for examining the neon light reflected from one mirror, or both mirrors, at various angles of incidence.

Dimensions, over-all: height, 10 inches; width, 15¾ inches; depth, 4¼ inches. Swiveling arm with pointer is 11½ inches long, 9 inches high. Complete with mirrors, swiveling light source, No. 84990 Neon Glow Lamp for 115 volts A.C. or D.C., and connecting cord and plug. **Each \$43.50**

10% discount in lots of 3

For experiments employing this or similar apparatus see White Exp. 72, p. 358; Min. Exp. 105, p. 162; Tay. pp. 139, 150, 160; S. E. P. L61b. See list of Manual References, page 1000.

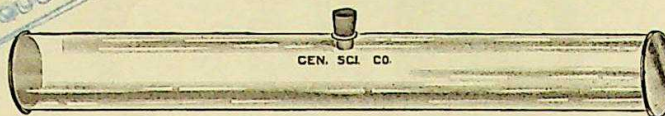
87518 POLARISCOPE, Polaroid, for teaching principles of polarization and for working with polarized light in the laboratory. Can be used as a vertical polariscope for examining crystals and other specimens requiring no magnification; as a polarizing illuminator for converting standard microscopes into polarizing instruments for the examination of textile fibers, biological sections, etc.; and as a horizontal polariscope for observation of specimens immersed in a liquid, observations requiring material and index matchings, and other examinations in which the specimen can be manipulated more conveniently from above than from the side. The polariscope can be set up in various ways for quantitative measurements, for qualitative observations, and for demonstration and study of the principles of operation of polarization instruments.

Consists of a metal base containing a 15 watt incandescent lamp with switch and supporting the lower glass stage. A small support rod holds the circular upper stage, the height of which can be varied. Stage clips are provided for holding the analyzer. A monochromatic light source may be installed in the lamp housing. The instrument is equipped with a 2 x 3 inch polarizer and an analyzer of 2½ inches diameter. Complete with lamp, polarizer, analyzer and connecting cord and plug for use on 115 volts A.C. or D.C. **Each 75.00**

87624 QUARTERWAVE PLATES, Glass, Polaroid, for use with No. 87518 Polariscop. Consists of a pair of rimless, edge-ground disks of Polaroid quarterwave glass. Diameter, 1¾ inches. Thickness, 0.10 inch. In cardboard case. **Per pair 12.50**

87624A QUARTERWAVE PLATE, Glass, Polaroid, similar to No. 87624, but a single plate instead of a pair. **Each 6.25**

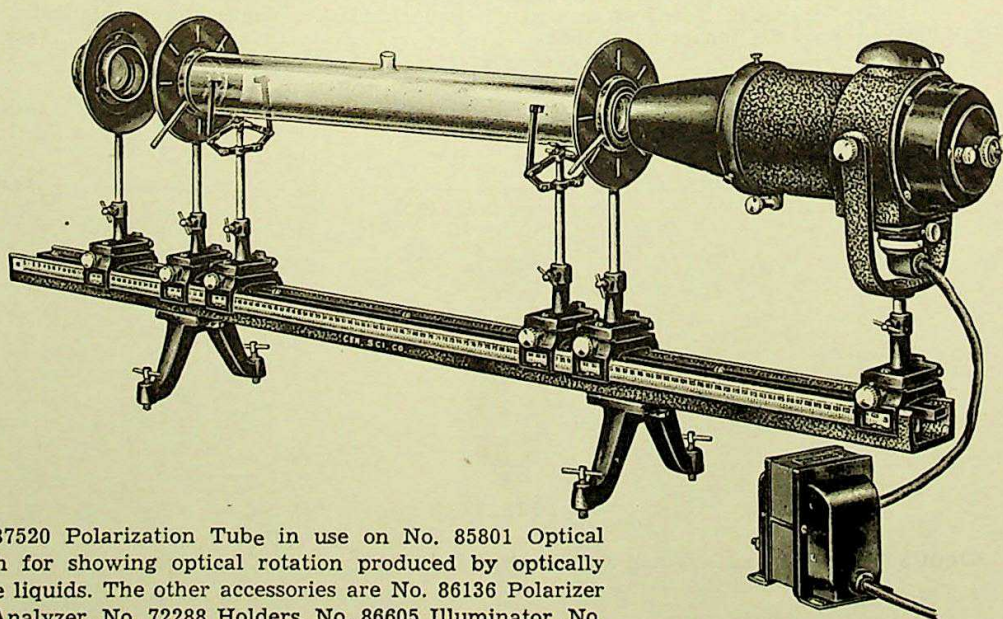
"Polaroid" Quantity Discounts: \$100.00 list, assorted—less 10%; \$200.00 list, assorted—less 15%.

LIGHT
Polarization

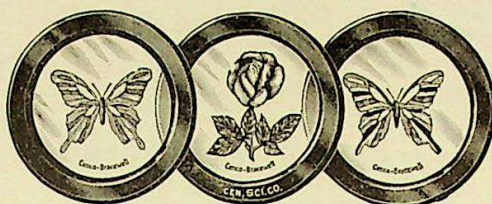
87520

87520 POLARIZATION TUBE, Demonstration Type, Cenco Design, for demonstrating the rotation of the plane of polarization by a sugar solution. The polarization tube is a highly instructive piece of lecture equipment by means of which the fundamental principle of the polarimeter may be shown to a class. It consists essentially of a glass polarimeter tube on a large scale, suitable for mounting on an optical bench and clearly visible from any part of the lecture room. Its construction is such that it can be filled with a sugar solution or some other doubly refracting liquid, and permanently sealed. It is about 60 cm long and 8 cm in diameter, and is provided with flat windows at the ends, cemented in place. A hole, with rubber stopper, is provided in the center of the tube, for filling. In use, a Polaroid disk polarizes a parallel beam of light from a source of high intensity which then enters the tube filled with a sucrose solution. This has sufficient turbidity to scatter some of the light. The particles that produce the scattering act as analyzers, since scattered light is more or less polarized. The various wave lengths in white light experience varying amounts of rotation of their plane of polarization by a given thickness of sugar solution. If, for example, the particles reflect light polarized vertically and extinguish light that is polarized horizontally, then, at any point in the solution, only those wave lengths which have a vertical component will be scattered by the particles, and the horizontal components will be extinguished. Thus, passing along the tube, we find a gradual variation of color, the resultant being white minus red, yellow, green, blue, etc., and the tube is filled with beautiful colors. They move along the tube as the polarizer is rotated. The effect is distinctly similar to the well known barber pole design, but with various colors. The Polarization Tube thus adds a strikingly beautiful experiment to the group of demonstrations in polarization. As described, **without** solution, but with directions **Each \$20.00**

10% discount in lots of 6



No. 87520 Polarization Tube in use on No. 85801 Optical Bench for showing optical rotation produced by optically active liquids. The other accessories are No. 86136 Polarizer and Analyzer, No. 72288 Holders, No. 86605 Illuminator, No. 86607 Light Shield, No. 86120 Projection Objective and No. 85802 Carriages

LIGHT
Polarization


87536

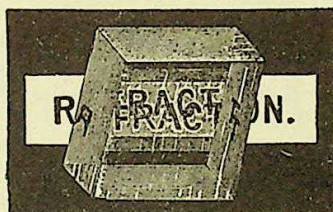
- 87535 POLARIZATION SPECIMENS, Interference Color, Cenco-Bracewell**, for impressive demonstration of the brilliant colors produced by interference arising from unequal rotation of the various wavelengths of plane polarized light in passing through designs made of doubly-refractive material. Colors may be observed either by examination of the specimens between a pair of Polaroid disks or by projection through crossed Polaroids.

The artistic figures are mounted between glass plates held in a protecting ring, approximately 55 mm in diameter. The clear aperture of 40 mm is almost completely filled by the figure.

No.	A	B	C
Subject	Butterfly	Rose	Butterfly
Number of colors.....	4	4	8
Each	\$4.50	6.75	9.00

10% discount in lots of 6

- 87536 POLARIZATION SPECIMEN SET, Interference Color, Cenco-Bracewell**, same as No. 87535 Polarization Specimens, but sold as a set of 3.....**Per set 18.00**



87590-5

- 87585 PHOTOELASTICITY STRIPS**, for making strain specimens for photoelasticity studies in polarized light. Consists of a strip of transparent molded plastics which shows polarization. Dimensions: 6 by 6½ inches by ¼ inch.....**Each 1.15**

10% discount in lots of 12

- 87590 ICELAND SPAR**, showing double refraction; ordinary quality.....**Each .15**

10% discount in lots of 50

- 87595 ICELAND SPAR**, best quality.....**Each .35**

10% discount in lots of 24

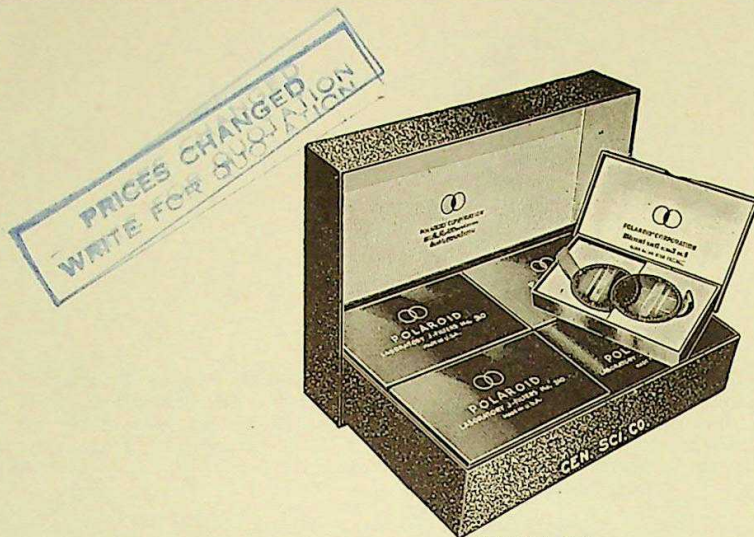


87600

- 87600 NICOL'S PRISMS**, for polarization, with diagonal face, cut in rhomboidal section.

No.	A	B	C	D
Size of face, millimeters.....	6	8	10	12
Each	8.25	20.00	20.00	31.00

10% discount in lots of 6

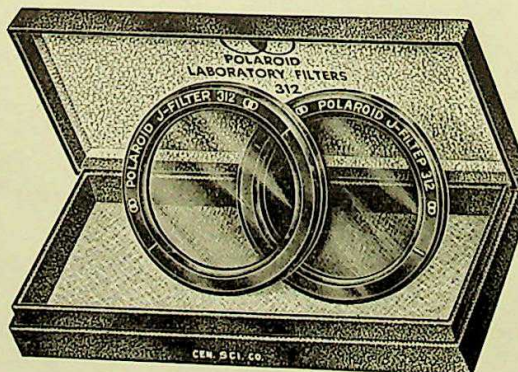
LIGHT
Polarization

87601A & B

87601A POLARIZING FILTERS, Polaroid Glass, Rimless, for laboratory experiments and demonstrations with polarized light. Large scale projections not possible with Nicol prisms are easily accomplished by the use of these filters. They also find application in the construction of devices in which specular reflections are to be reduced or eliminated, or in which transparent specimens reveal characteristics through their polarization of transmitted light.

Consists of a pair of rimless, edge-ground glass disks, $1\frac{3}{4}$ inches in diameter, each composed of a lamination of dichroic sheet polarizer material between thin glass plates. A 180-degree scale of angles, with 5-degree intervals, is permanently etched around half its periphery and its name and an identifying number appear around the other half. The polarizing axis is indicated by a diamond-shaped index in the center of the angular scale. The optical properties of the cellulosic film are produced through the uniform orientation of many millions of dichroic synthetic crystals in each square inch of area. The crystalline structure is too fine to be visible at 1100 magnifications. Through the dichroism of these crystals, one component of the light in the visible spectrum is absorbed while the other is transmitted without appreciable modification. Polarization is complete except at the extreme ends of the visible spectrum, where eye sensitivity is low. Fully 99.5% of visible light is polarized. Age, ultraviolet light, and temperatures below 130° F do not affect the polarizing film. In cardboard case Per pair \$4.50

87601B POLARIZING FILTER SET, Polaroid Glass, Rimless, for class experiments with polarized light. Consists of 12 pairs of No. 87601A Filters with one No. 87633 Handbook and one No. 87635 Manual. Each pair of disks is packed in a cardboard case and the entire set in a cardboard carton Per Set 50.00

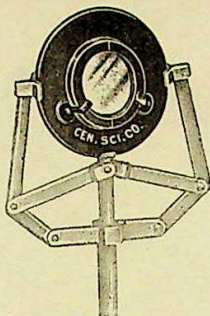


87602

87602 POLARIZING DISKS, Rimmed, Polaroid Glass, same as No. 87601 Polarizing Filters, but mounted in shock-resistant rims of molded plastics. A clear aperture of 4 cm is provided, which is over three times that of the largest Nicol prisms regularly listed. In leatherette-covered metal case Per pair 6.00

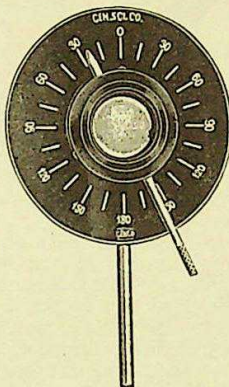
"Polaroid" Quantity Discounts, See Footnote, Page 1432.

LIGHT
Polarization



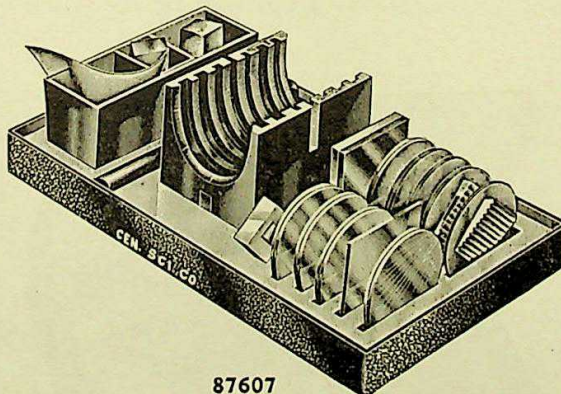
87603

- 87603 POLAROID DISK MOUNTING**, for loosely holding standard rimmed or rimless Polaroid Disks in a No. 72288 Lens Holder to permit easy rotation in performing demonstrations with polarized light. Consists of a circular metal disk, 4 inches in diameter, having a circular aperture, $1\frac{5}{8}$ inches in diameter, over which the Polaroid Disk is loosely held by two small lugs in such a manner as to permit easy rotation. **Without Polaroid Disk**.....Each \$2.85
10% discount in lots of 6



87604A

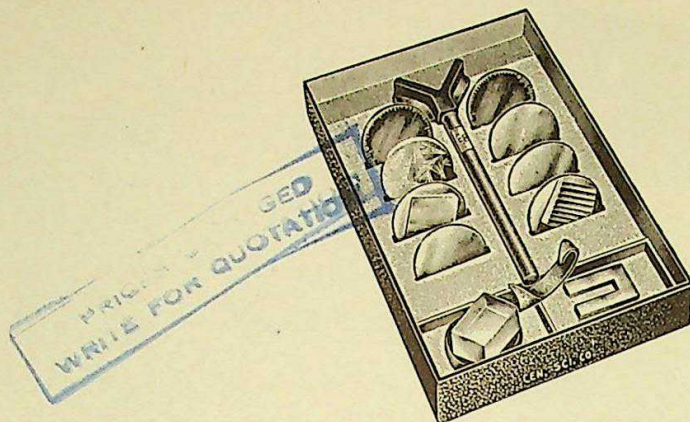
- 87604A POLAROID DISK MOUNTING, Optical Bench Type**, to permit introducing and manipulating No. 87601A Polaroid Disks of the rimless type in an assembly on an optical bench equipped with carriages for accessories with support rods. Cannot be used with No. 87602 Rimmed Disks. Consists of the mounting only, **without Polaroid Disk**.....Each 21.50
10% discount in lots of 6



87607

- 87607 POLAROID EXPERIMENTAL KIT, Projection Type**, for performing experiments and demonstrations with polarized light on an optical bench or projector, using No. 87602 Polaroid Disks. The kit includes an instruction book giving full directions and diagrams for performing eighteen demonstrations.
The kit consists of a convenient holder for the Polaroid Disks and accessories; a calcite crystal; a black glass mirror; a sheet of diaxial mica; a slide of synthetic retardation strands; two synthetic retardation plates; a slide of large-needle crystals; two multiple-layer retardation slides; a photoelastic plastics block; a photoelastic crescent; a photoelastic U; a synthetic pleochroic slide; and extra glass disks for preparation of natural crystal slides. With instruction book, but **without polaroid disks**.....Per set 35.00

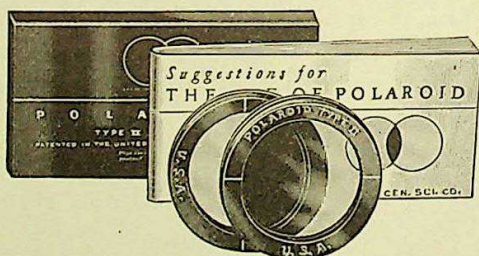
"Polaroid" Quantity Discounts, See Footnote, Page 1432.

LIGHT
Polarization

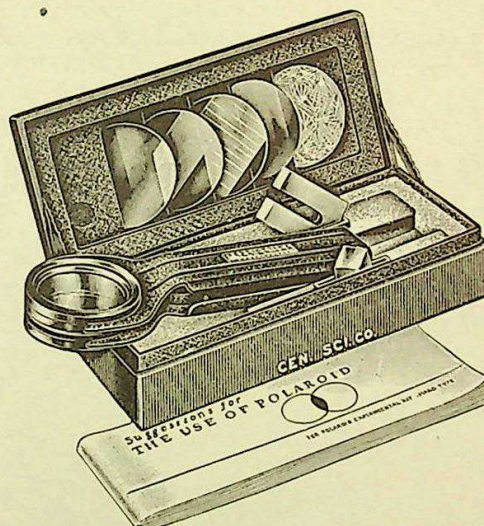
87609

87609 POLARIZED LIGHT EXPERIMENTAL KIT, Polaroid for experiments and demonstrations on the optical bench, with a projection lantern or by hand.

Consists of a pair of No. 87601A Polarizing Filters, a metal V-block with transverse slots to accommodate polarizers and accessories, a $\frac{3}{8}$ inch rod to permit use of the V-block on an optical bench, a set of accessories, a No. 87633 Handbook, and a booklet of instructions for using the kit. The accessories include a number of specimens, most of which are mounted on glass plates, for demonstrating polarization of light and its applications. In black cardboard case with receptacles for each item.....**Each \$15.50**



87615



87616

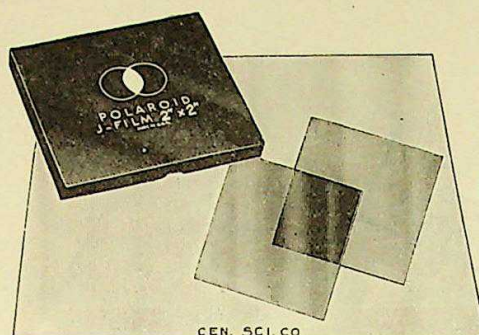
87615 POLARIZING DISKS, Rimmed, Polaroid Film, similar to No. 87602 Polarizing Disks in optical properties, but constructed of less expensive materials.

The disks consist of a rimmed area of polarizing film welded between layers of clear acetate film, with an aperture of approximately 40 mm and an over-all diameter of approximately 55 mm. The transmission of the film is approximately 36%, and of the transmitted light, over 99.5% is plane polarized. As they are unbreakable, they are to be recommended for all student purposes. They are not recommended for projection purposes. Each pair of disks is packed in a neat, black, paper-covered cardboard box with an instruction manual describing Polaroid and its uses in laboratory experiments and lecture demonstrations..**Per pair 2.50**

87616 POLAROID EXPERIMENTAL KIT, Hand Type, similar to No. 87607 Polaroid Projection Kit, but furnished with a pair of No. 87615 Type II Polaroid Disks and a hand polariscope fixture in which the disks are held for conducting the experiments. Not as many specimens are supplied with this kit as with the No. 87607 Kit. The specimens are: a small calcite crystal; a photoelastic U; a black mirror; a disk of biaxial mica for interference; a disk with a stepped retardation series; a disk with retardation wedge to show progression of interference colors; and an instruction book. The kit is arranged in an attractive, velvet-lined, pocket case.....**Per set 14.50**

"Polaroid" Quantity Discounts, See Footnote, Page 1432.

LIGHT **Polarization**



87618A

87618A POLARIZING FILTERS, Polaroid Film, for construction of devices employing polarized light, such as demonstration polariscopes, microscope polarizing attachments, light intensity controls, strain testers, etc.

Consists of a pair of 2-inch squares of dichroic sheet polarizer material welded between layers of clear photographic safety film. The film is unbreakable and somewhat stiffer and stronger than celluloid of the same thickness. It is easily cut with a scissors. Each film is enclosed in a cellophane envelope that will produce excellent colors between the two polarizing films. Complete with instruction sheet in small leatherette case.....**Per pair \$1.00**

87618B POLARIZING FILTER SET, Polaroid Film, for class experiments with polarized light. Consists of 24 pairs of No. 87618A Filters with one No. 87633 Handbook and one No. 87635 Manual. Each pair of filters is packed in a leatherette case and the entire set in a cardboard carton.**Per set 24.00**

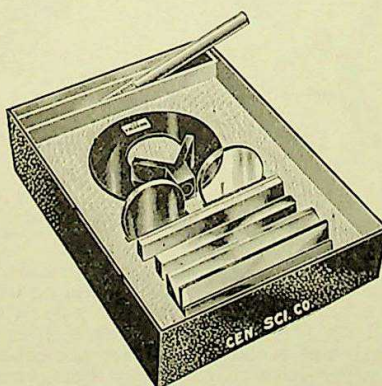
87619 POLARIZING FILTERS, Polaroid Film, same as No. 87618A Filters, but in 6-inch squares. Each film is enclosed in a cellophane envelope. Complete with instruction sheet in cardboard case.

No.	A	B
Package of	single sheet	pair
Per Package	3.50	6.50

87620B POLARIZING FILTERS, Polaroid Film, same as No. 87618A Filters, but in 12-inch squares. Each film is enclosed in a cellophane envelope. Complete with instruction sheet in cardboard case.**Each 12.00**

87624 QUARTERWAVE PLATES, Glass, Polaroid, for use with No. 87518 Polariscopes or for research in photoelasticity. Consist of a pair of rimless, edge-ground disks of Polaroid quarterwave glass. Diameter, 1 3/4 inches. Thickness, 0.15 inch. In cardboard case.....**Per pair 12.50**

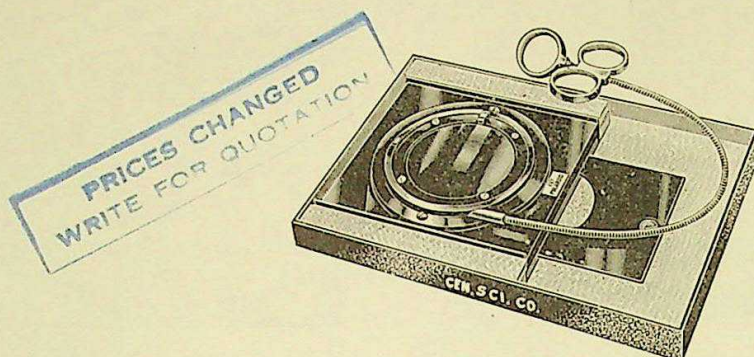
87624A QUARTERWAVE PLATE, Glass, Polaroid, similar to No. 87624, but a single plate instead of a pair.**Each 6.25**



87625

87625 POLARIZED LIGHT KIT, Optical Disk, Polaroid, for use on No. 85245 Optical Disk to adapt it to demonstrations of polarized light. Consists of single polarizing filter of No. 87601A Filters, a metal V-block with light shield, a set of accessories with manual of instructions, and a No. 87633 Handbook on Polarized Light and its Application. The accessories include a strip of black glass, a strip polarizing filter of Polaroid Glass, a doubly refracting disk, and a viewing unit, which renders reflected rays of light on the face of the instrument doubly visible in the classroom. In black cardboard case.....**Each 12.50**

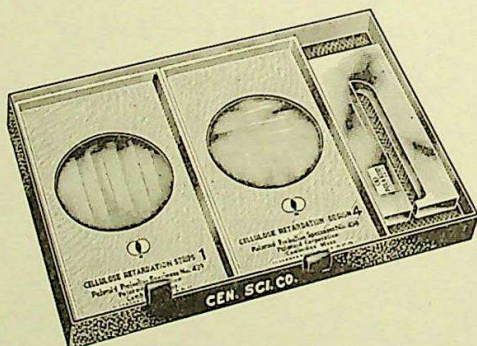
"Polaroid" Quantity Discounts, See Footnote, Page 1432.

LIGHT
Polarization

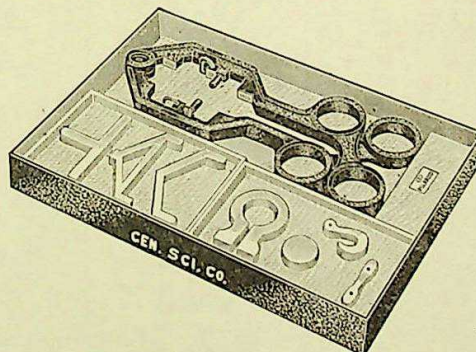
87626

- 87626 PROJECTOR POLARISCOPE, Polaroid**, for striking demonstrations with polarized light employing a standard projection lantern. Fits in the space ordinarily occupied by the slide holder. Especially suited to use with long-focus projection lenses which limit the solid angle within which light traverses the polarizers and specimens. May be used on a No. 85801 Cenco Optical Bench when a No. 72162 Rod is screwed into the threaded hole provided for this purpose. Will withstand exposure in a 500-watt lamp projection lantern for long periods of time without damage.

Consists of a rotatable back polarizing element and a removable front polarizing element in a metal housing, which has transverse slots at the top and bottom, between the polarizing elements, to accommodate No. 87627 Specimen Slides. The space is adequate to permit insertion of the special pliers of No. 87628 Photoelastic Demonstration Set. The back element can be rotated through an arc of about 100 degrees by means of a convenient plunger control. It is made with a special type of film that renders it as nearly heat resistant as possible. The front element, whose orientation is fixed at 45 degrees to the vertical, is mounted on a sliding plate so that it can be removed when the polariscopes is used for a demonstration involving an external polarizing process.....**Each \$12.75**



87627



87628

- 87627 PROJECTOR SPECIMEN KIT, Polaroid**, for use with No. 87626 Projector Polariscopes for demonstrations of polarized light with an ordinary projection lantern.

Consists of 5 slides, each $3\frac{1}{4}$ by $5\frac{3}{4}$ inches; a piece of plain glass of the same size; a piece of heat-treated glass; and a large plastic U for photoelastic effects. One of the slides contains a layer of doubly-refracting material for use in producing color effects with an external polarizing process, such as reflection from a piece of glass or scattering in a turbid liquid. Another slide contains a cellulose picture to illustrate the use of interference colors for advertising displays. Complete with instructions for use and a No. 87633 Handbook. In black cardboard case**Each 12.75**

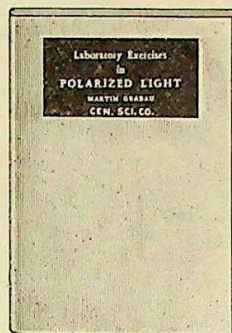
- 87628 PHOTOELASTIC SPECIMEN KIT, Polaroid**, for use with No. 87626 Projector Polariscopes on an ordinary projection lantern for showing photoelastic strain effects of various kinds. Consists of a specially designed pair of pliers for subjecting specimens either to tension or compression and a set of six molded, transparent bakelite specimens. Complete with instructions for use and a No. 87633 Handbook. In black cardboard case.....**Each 12.75**

"Polaroid" Quantity Discounts, See Footnote, Page 1432.

LIGHT
Polarization
Optics of Vision



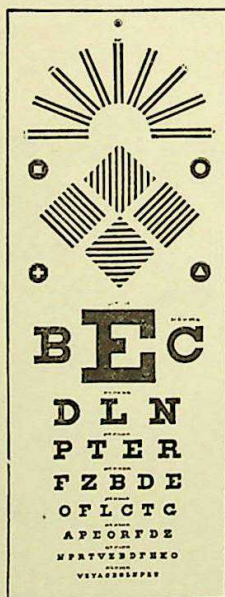
87633



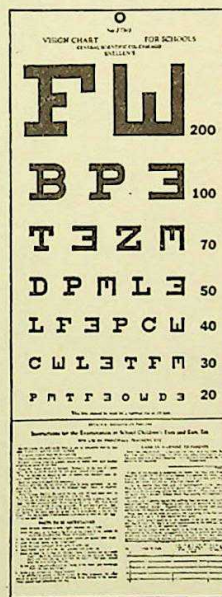
87635

- 87633 POLARIZED LIGHT HANDBOOK**, *Introduction to Polarized Light and Its Application*, an elementary textbook on polarized light to supplement the discussions of the subject in existing textbooks. Explains the nature of polarized light and the functional behavior of light polarizers in great detail. Major applications are segregated into a separate chapter for detailed discussion. Each student in the class should be provided with an individual copy for effective teaching of the subject. Consists of a 48-page booklet, 5½ by 8½ inches in size, with numerous diagrams and illustrations.....Each \$0.50

- 87635 POLARIZED LIGHT LABORATORY MANUAL**, *Laboratory Exercises in Polarized Light*, for individual student use as a guide in conducting experiments in polarized light with Polaroid filters. Illustrated outlines are given for three experiments: A general exercise embodying qualitative observations; an exercise for the determination of the index of refraction of glass by observations of the polarizing angle; and an exercise involving rotation of the plane of polarization of light in sugar solutions and turpentine. Consists of a booklet of 16 pages, 5½ by 8½ inches in size, with illustrations.....Each .35



51270



51272

- 51270 EYE TEST CHART**, Cenco, for testing the vision of pupils. Consists of a series of type sizes and astigmatic diagrams printed upon a heavy bristol board with eyelet for hanging. It is made in 4 parts with cloth hinges to permit folding to 27 by 19.5 cm. The manila container is printed with the instructions for use.Each .50

10% discount in lots of 12

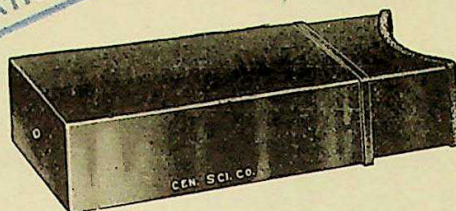
- 51272 EYE TEST CHART**, Allport's, a larger and improved form of the Snellen chart, which furnishes a simple method for testing the vision of school children. It is printed upon heavy bristol board, with eyelet for hanging and with a lower part, containing the instructions for use, arranged for removal, leaving a chart measuring 26.5 by 49 cm.Each .25

10% discount in lots of 36

PRICES CHANGED
WRITE FOR QUOTATION

359/896

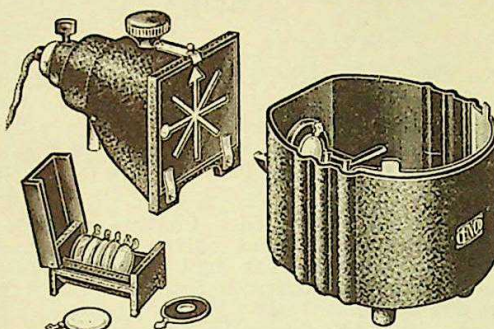
LIGHT
Optics of Vision



87645

87645 **CAMERA OBSCURA**, students' form, of metal, according to Hall and Bergen. Consists of two telescoping boxes, one with pin hole, the other with ground glass plate. Excellent for showing the principles of the photographic camera and the formation of images. Size, closed, about 5 by 12 by 22 cm. Each \$8.00

10% discount in lots of 6



87660

87660 **EYE MODEL**, Cenco-Ingersoll (Patent No. 1,630,944), for giving the student a better grasp of the fundamental optics of vision than he could possibly get from a mere textbook description. Originally suggested by Prof. L. R. Ingersoll, who has used the outfit with great success for years. The simplicity of the apparatus makes it admirably suited for use in elementary classes of biology, physics and general science; at the same time it provides a variety of demonstrations, the explanations of which may properly be required of students of higher grade. It makes an excellent laboratory experiment in Physics and Biology.

A set of seven lenses of different kinds, of the type used by opticians in ascertaining defects of the eye, and one diaphragm are supplied as part of the eye model. In use, the model is partially filled with water to represent the fluids in the eyeball.

No. 87664 Object Box provides an illuminated object of special pattern with which some of the defects of "vision" can be determined. Use of the apparatus permits study and demonstration of the following phenomena which are associated with normal and defective vision:

1. **Normal Vision.** The functions of the retina, cornea, crystalline lens and iris, and the character of the image, the location of the blind spot, etc., may be studied.
2. **Accommodation.** This is the process by which the eye forms a distinct image of objects at different distances. This is shown by the use of lenses of different focal lengths which corresponds to change in focal length of the crystalline lens.
3. **Nearsightedness (Myopia) and Farsightedness (Hypermetropia)** are shown by varying the distance between the lens and the retina by fixed amounts.
4. **Astigmatism.** Its cause, the method of diagnosis, and the means for correction are shown.
5. **Compound Defects.** A combination of several defects and the correction of the particular combination are shown.
6. **Vision without Crystalline Lens.**
7. **Simple magnifier** and its effect on the retinal image.

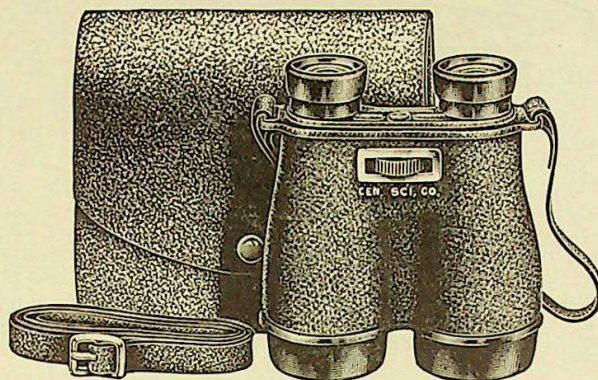
Complete as described, with a complete set of No. 87666 Lenses, No. 87664 Object Box with No. 84450C, 115-volt Lamp, self-contained switch, and 6 feet of connecting cord with plug. Each 50.00

10% discount in lots of 3

R50

359/896

LIGHT
Optics of Vision
Field Glass



87681

- 87662 EYE MODEL**, only, of No. 87660 Apparatus, for those who already have an image box. Supplied with a complete set of No. 87666 Lenses.....**Each \$37.00**

10% discount in lots of 6

For experiments employing this or similar apparatus, see I. & M. Exp. 77, p. 261; White Exp. 66, p. 333; Min. Exp. 93, p. 114; S. E. P. Lab. See list of Manual References, page 1000.

- 87664 OBJECT, Optical**, only, of No. 87660 Eye Model. Consists of eight slots, in a plate of black-finished brass, spaced at equal angles and radiating from a common center. One of the slots is provided with an arrow tip; another, at right angles to the first, terminates in a circular aperture. This pattern enables the student to determine easily the point-to-point correspondence between object and image.

The pattern plate is held by clips in front of and in contact with a ground glass plate, both of which fit in a recess in the front of a substantial metal housing. The housing has a light diffusing, reflecting finish inside, and is finished wrinkle black outside. A lamp socket, with switch key and connecting cord, is mounted in the housing, and a No. 84450C Incandescent Lamp Bulb for 115 volts is supplied. An evenly illuminated pattern is secured, bright enough to be used in the diffused light of an ordinary laboratory. Normally, the center of the pattern plate is 75 mm above the table. No. 72162 Rod may be used in place of the stud when it is desired to use the object box on an optical bench, such as No. 85801.....**Each 12.50**

10% discount in lots of 6

For experiments employing this or similar apparatus, see I. & M. Exp. 77, p. 261; White Exp. 66, p. 333.

- 87666 Lenses**, only, of Nos. 87660 and 87662 Eye Models, for replacement. All the lenses are 38 mm in diameter. Lens A is unmounted, being a meniscus lens which may be used for replacing the "cornea" in the eye model. The other lenses are mounted in metal holders on the handles of which are stamped the focal length in diopters and the kind of lens.

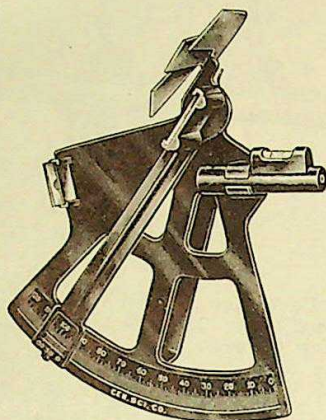
No.	A	B	C	D
Kind of lens.....	meniscus	double convex	double convex	convex
Focal length, diopters.....	+3.00	+7.00	+20.00	+2.00
Each	1.75	1.55	2.65	1.55
No.	E	F	G	
Kind of lens.....	concave	concave cylindrical	convex cylindrical	
Focal length, diopters.....	-1.75	-5.50	+1.75	
Each	2.30	2.15	1.55	

10% discount in lots of 6

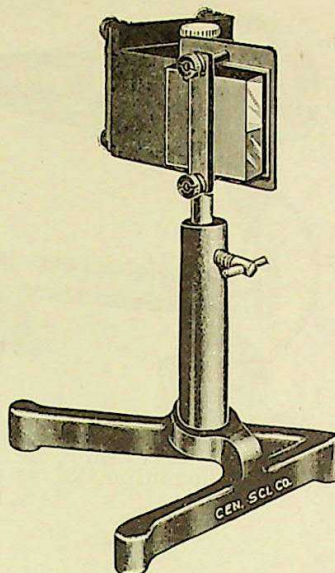
- 87681 FIELD GLASS, Magni-Vu, Binocular**, for stereoscopic observation of distant objects under a magnification of 3.5 diameters. An excellent glass for use in the study of birds and animals. The lenses are set in dust-proof, rubber-sealed, black plastics housings; the lightweight aluminum body is finished in black wrinkle enamel. A knurled knob permits focusing; lenses are matched and corrected for chromatic aberration and maximum clarity over an extremely wide field of view. Diameter of objectives, 40 mm; field of view at 1000 yards, 570 feet; interpupillary distance, 60 mm; height collapsed, 5 inches; width, 4½ inches; diameter of barrels, 2 inches. Weight, 1 lb. Complete with neck strap and carrying case.....**Each 11.50***

*Federal Excise Tax Extra, if applicable.

PRICES CHANGED
WRITE FOR QUOTATION



87697



87761

LIGHT
Lecture Prism

87697 SEXTANT, Student Type, for demonstrating the principles and operation of the mariner's sextant for determining latitude of a point on the earth's surface. May also be used for measuring horizontal angles for locating points in map making and for measuring by triangulation heights of objects or distances between points that cannot be measured directly.

Made of brass and finished with black lacquer. The index arm carries a vernier, which reads to 6 minutes. The angular scale is graduated in raised lines with raised figures from 0 to 120 degrees in $\frac{1}{2}$ degree divisions. The sight tube is provided with an index point for use as an artificial horizon, when the actual horizon cannot be seen. Since the instrument must be held perfectly level when the artificial horizon is used, a level bubble-tube is provided on the top of the sighting tube. Three adjustable colored filters are provided for use when "shooting the sun" to reduce its brilliance to a spot of light of convenient intensity for easy observation. The movable mirror is of back-silvered glass and the fixed mirror is half back-silvered and half clear. Length of graduated scale, $5\frac{1}{2}$ inches. Length of index arm, 6 inches. Complete with booklet giving instructions for various uses of the sextant and a table of sun declination.....

Each \$4.95

10% discount in lots of 6

87761 PRISM, LECTURE TABLE, Eaton's Direct Vision, Cenco-Improved Form, for producing an intense spectrum in teaching the subjects of diffraction, dispersion and color.

Eaton's Direct Vision Prism is a splendid lecture table device for the purpose of having a fairly long spectrum, in which the different colors may be clearly differentiated. A prism of crown glass, of special form, is combined with a liquid prism, such as carbon bisulphide, benzol, bromoform or other liquid having high dispersive power. The glass prism forms one side of the vessel containing the liquid. The other transparent side of this vessel consists of a piece of plane-parallel plate glass.

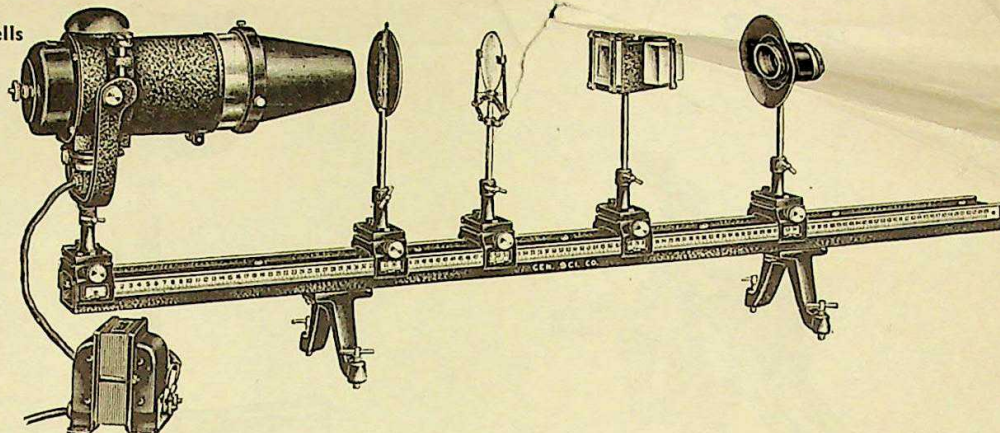
This prism, when used with an arc (such as No. 85261 Illuminator) gives a continuous spectrum, with little deviation, of high intensity. When a metal spectra apparatus is used as the illuminant, the bright-line spectrum of the metals can be demonstrated to a large class. The dispersion when carbon bisulphide is used is about 30° under favorable circumstances. The inside and outside of the case are black oxidized, a finish that will not be dissolved by the liquids used. Having the case black inside is important because it prevents reflections that would otherwise destroy the purity of color in the spectrum. The case is mounted on a nickel-plated support rod, $\frac{3}{8}$ inch (10 mm) in diameter and 15 cm long, which will telescope into a heavy base support such as No. 72202. The rod also permits the use of the prism on the bed of a projection lantern. Dimensions of prism: length over-all, about 12 cm; width over-all, 7.5 cm; height, 7.5 cm. Capacity of prism, about 250 ml. Complete as described, but without support.....

Each 33.75

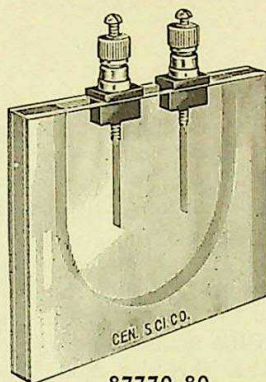
10% discount in lots of 3

(See illustration on following page)

**LIGHT
Projection Cells**



No. 87761 Eaton's Prism in use on No. 85801 Optical Bench for spectrum projection. Showing No. 86605 Illuminator, No. 86140 Slit, No. 85645 Lens in No. 72288 Holder, No. 87761 Prism, and No. 86120 Projection Objective.



87770-80

- 87770 CELL, Projection, Glass,** for projecting demonstrations of capillary action, effects produced by specific gravity of liquids, chemical action, etc. Will fit into the slide stage of any projection lantern using a standard slide carrier. Not materially affected by acid or alkali. Dimensions: 10 cm high, 12.5 cm long.....**Each \$6.85**

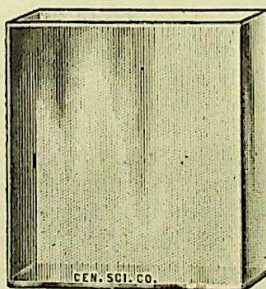
10% discount in lots of 6

- 87772 Electrodes,** for use with No. 87770 Projection Cell for the demonstration of electrolysis. Of platinum, with binding post.....**Per pair 5.75**

10% discount in lots of 6 pairs

- 87780 CELL, Projection, Electrolytic.** Consisting of No. 87770 Cell with No. 87772 Electrodes....**Each 12.60**

10% discount in lots of 6



87790

- 87790 PROJECTION CELL, "Pyrex" Brand Glass,** for projecting an image of the cell contents on a screen. Developed according to the suggestions of Prof. R. T. Dufford of the University of Missouri. All corner seams are fused—not cemented—so that there is no possibility of leakage or failure of the cell along the corners. Being of "Pyrex" brand glass, it will withstand wide temperature variations. The base is plane and broad enough to enable the cell to stand upright on a flat top support like Nos. 72545 or 72556 Support Platforms. Approximate outside dimensions: height, 11.5 cm; width, 11 cm; depth, 3 cm.....**Each 8.75**

10% discount in lots of 6